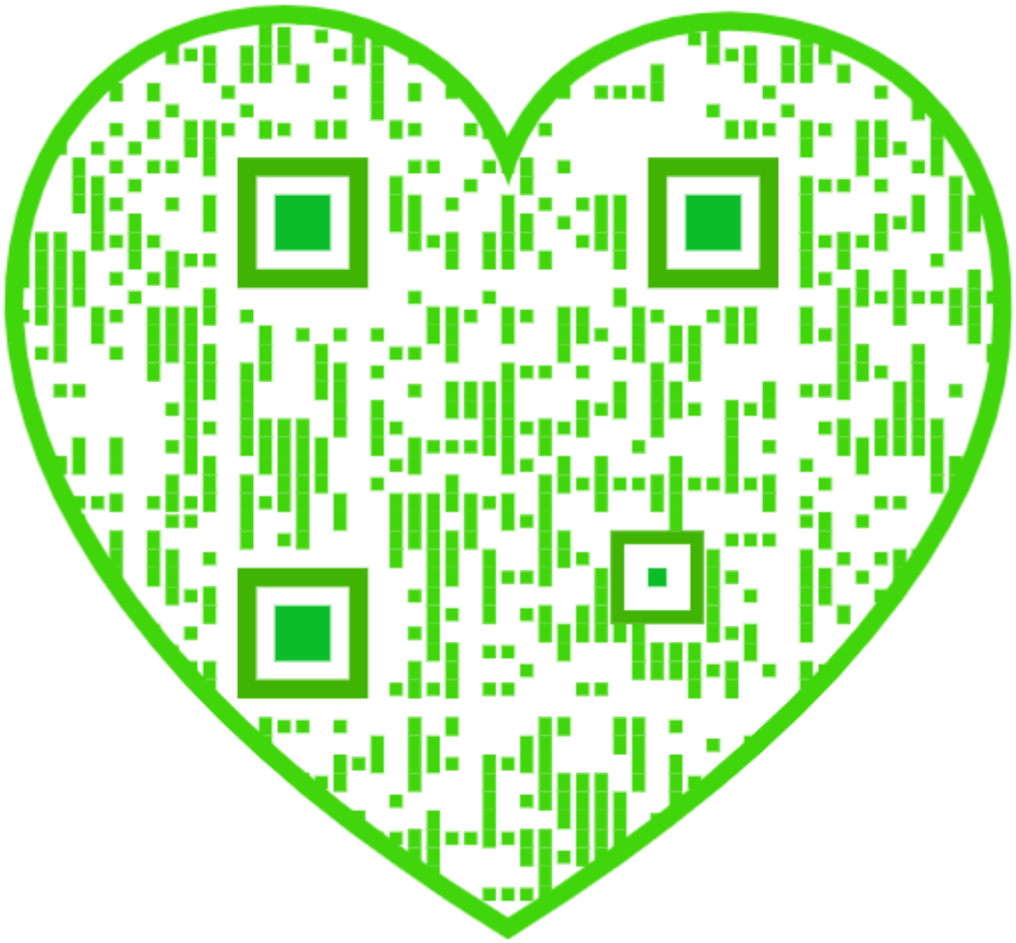

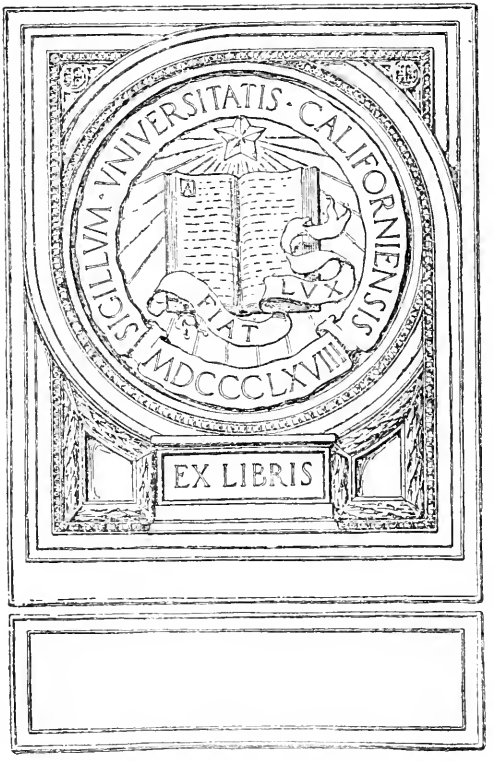
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MOUTH HYGIENE

A TEXT-BOOK FOR DENTAL HYGIENISTS

COMPILED AND EDITED BY

ALFRED C. FONES, D.D.S.

BRIDGEPORT, CONNECTICUT

SECOND EDITION, THOROUGHLY REVISED

With 218 Illustrations and 8 Plates

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1921

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PREFACE TO THE SECOND EDITION.

Five years have passed since the publication of the first edition of Mouth Hygiene, and during that period a number of schools have been organized for the education and training of the dental hygienist. The experience of these schools has shown that several of the fundamental subjects, such as anatomy, physiology, bacteriology, hygiene etc., require more extensive text than could be adequately covered in any one book. It is, therefore, recommended that standard text-books be utilized for such subjects.

The second edition of Mouth Hygiene endeavors to meet the need of the dental hygienist for those subjects which pertain directly to dentistry and which are essential to her education.

A. C. F.

Bridgeport, Conn., 1921.

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CONTENTS.

CHAPTER I.

ANATOMY OF THE HEAD 17
By Robert H. W. Strang, M.D., D.D.S.

CHAPTER II.

HISTOLOGY OF THE TEETH AND ASSOCIATED STRUCTURES . 58
By Robert H. W. Strang, M.D., D.D.S.

CHAPTER III.

THE TEETH AS A MASTICATING MACHINE 80
By Charles R. Turner, M.D., D.D.S.

CHAPTER IV.

MALOCCLUSION OF THE TEETH 112
By Rodrigues Ottolengui, M.D.S., D.D.S., LL.D.

CHAPTER V.

INFLAMMATION 136
By Leroy M. S. Miner, M.D., D.M.D.

CHAPTER VI.

DEPOSITS AND ACCRETIONS UPON THE TEETH 149
By Edward C. Kirk, D.D.S., Sc.D., LL.D.

CHAPTER VII.

PYORRHEA ALVEOLARIS 166
By Arthur H. Merritt, D.D.S.

CHAPTER VIII.

DENTAL CARIES 173
By Edward C. Kirk, D.D.S., Sc.D., LL.D.

CHAPTER IX.

ODONTALGIA AND NEURALGIA 191
By Arthur Hopewell-Smith, Sc.D., L.R.C.P., M.R.C.S., L.D.S.

CHAPTER X.

THE RELATION OF ORAL INFECTIONS TO GENERAL HEALTH . 203
By Kurt H. Thoma, D.M.D.

CHAPTER XI.

DENTAL PROPHYLAXIS 223
By Alfred C. Fones, D.D.S.

APPENDIX 299

MOUTH HYGIENE.

CHAPTER I.

ANATOMY OF THE HEAD.[1]

By ROBERT H. W. STRANG, M.D., D.D.S.

THE SKULL.

The twenty-two bones that enter into the formation of the osseous framework of the head are united by immovable joints, the lower jaw excepted, called sutures. These form a strong supporting and protecting structure termed the skull (Fig. 1). This may be conveniently studied under four headings: (*a*) the cranium; (*b*) the base; (*c*) the lateral aspect; (*d*) the anterior aspect or face.

The Cranium.—The cranium comprises that portion of the skull which contains the brain. It is formed by the union of eight bones which are named as follows: frontal, two parietal, occipital, two temporal, sphenoid and ethmoid. In outline it is somewhat egg-shaped and presents for study a superior surface, forming the *vertex* of the skull, and an inferior surface.

The *external surface of the vertex* is convex and is covered in the living subject by the tissues that form the scalp. This convexity of surface is ideal for the resisting and warding off of blows. This surface is traversed by three sutures arranged in the form of the letter "H." The anterior cross suture which is situated well toward the top of the skull is called the *coronal;* the one passing from this to the posterior cross suture is the *sagittal;* the posterior transverse suture is the *lambdoid.*

The *internal surface of the vertex* is concave and is marked with elevations and depressions for the accommodation of the irregular brain surface. Through the center, running anteroposteriorly, is a groove in which lies the superior longitudinal sinus, a blood channel performing the function of a vein and carrying part of the return blood from the brain. To the margins of this groove are attached some of the supporting membranes of the brain.

[1] BIBLIOGRAPHY: Gray's Anatomy; Piersol's Anatomy; Cryer, Internal Anatomy of the Face; Deaver, Special Anatomy of Head and Neck; Swan, Manual of Anatomy; Chapter on Anatomy of the Teeth, by C. R. Turner, in Johnson's Operative Dentistry.

There are also numerous smaller grooves in the bony surface which radiate in various directions and in appearance resemble the branches of a tree. In these run the ramifying branches of the middle meningeal artery which supplies the cranial bones and dura mater with blood.

The *inferior surface of the cranium* corresponds to the cerebral surface of the base of the skull (Fig. 2). It is divided by two transverse ridges into three planes, arranged like terraces with the anterior one on the highest level. These planes bear the name of *fossæ* and are called according to their position, anterior, middle and posterior. Their surfaces are more or less irregularly concave, grooved to accommodate bloodvessels and perforated in many places to allow these vessels and also nerves to pass in and out of the cranium.

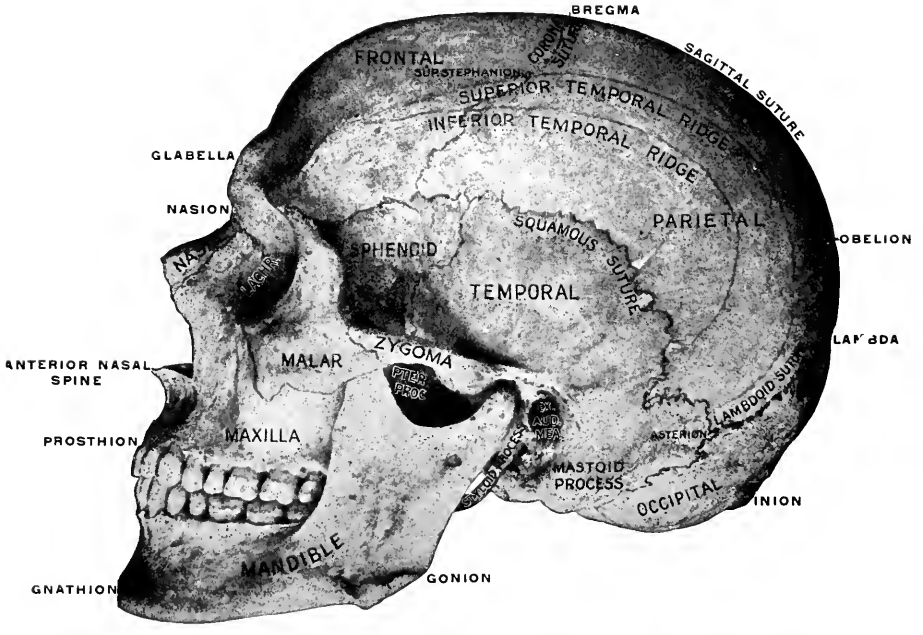


FIG. 1.—Side view of typical skull. According to the present nomenclature the bone marked malar should be zygoma and that zygoma should be zygomatic arch. (Cryer.)

Description of the Fossæ.—Anterior Fossa.—The points of interest in this fossa are (*a*) the prominent bony spine in the median line called the *crista galli* (cock's crest); (*b*) near the front end of this on either side, slit-like openings for the passage of the *nasal nerves* into the nasal cavity; (*c*) the cribriform plate of the ethmoid bone placed on a somewhat lower level than the rest of the floor of the anterior fossa forming what is known as the *olfactory groove*. This groove is divided anteroposteriorly by the crista galli, accommodates the olfactory bulb of the brain and has its floor piereed with many

openings for the passage of the olfactory nerves to the nasal cavities; (*d*) the anterior and posterior ethmoidal foramina, situated at the outer edge of the cribriform plate, the former at about the middle and the latter at the posterior end of the plate. The bone forming the floor of the anterior fossa roofs over the orbital cavities.

Middle Fossa.—In the middle fossa are seen (*a*) two openings that communicate with the orbits. The smaller of these is the *optic foramen*, transmitting the optic nerve and ophthalmic artery to the eye; the larger one is the *sphenoidal fissure* or *anterior lacerated foramen*, for the passage of the third, fourth, ophthalmic division of the fifth and the sixth cranial nerves, a sympathetic nerve, and also arteries and veins to and from the orbits; (*b*) in the center of the fossa a bony formation that resembles a saddle and for this reason is called the *sella turcica* (Turkish saddle). In this bony structure is situated the pituitary body, one of the so-called ductless glands, which secretes important hormones that exert a marked influence on growth and development; (*c*) on either side of this, four openings. The two anterior ones are of particular interest because through them pass the divisions of the fifth cranial nerve that go to the upper and lower teeth. The anterior opening is the *foramen rotundum* and it transmits the superior maxillary division of the fifth nerve. Behind this is the *foramen ovale* through which passes the sensory and motor portions of the inferior maxillary division of the same nerve. The smallest of the openings is the foramen spinosum through which the middle meningeal artery enters the skull. The largest of these four foramina is called the *middle lacerated foramen*. This is closed in the living subject with cartilage. On its posterior wall, however, is seen (*d*) the inner opening of the carotid canal through which the internal carotid artery gains entrance to the cranium.

The bone at the posterior aspect of the middle fossa acts as the roof for the middle and internal divisions of the ear and is somewhat irregular in conformation with their make-up.

Posterior Fossa.—The surface of this fossa is deeply concave and accommodates the cerebellum. It is marked with (*a*) grooves for the lateral sinuses carrying return blood from the brain. To the edges of these grooves is attached the membrane supporting the cerebellum. (*b*) The foramen magnum, centrally located, through which passes the spinal cord; (*c*) the anterior condyloid foramina for the passage of the hypoglossal nerves to the tongue; (*d*) the jugular or posterior lacerated foramina which affords a means of exit to the ninth, tenth and eleventh cranial nerves as well as the lateral sinuses; (*e*) the internal auditory meati for the passage of the auditory nerves and arteries and the facial nerves.

The Base of the Skull.—The *cerebral surface of the base* has just been described under the heading of the Inferior Surface of the Cranium (Fig. 2).

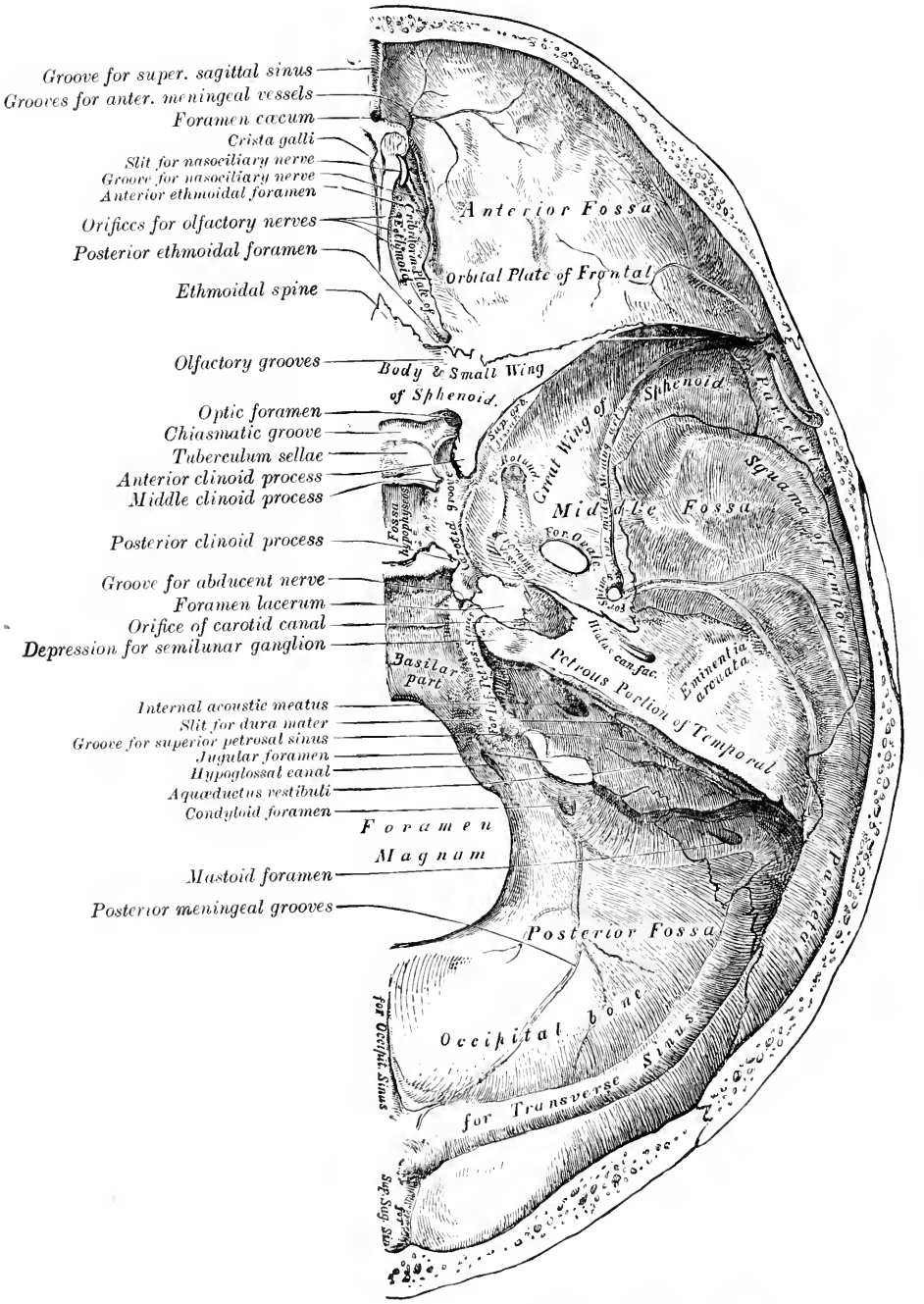
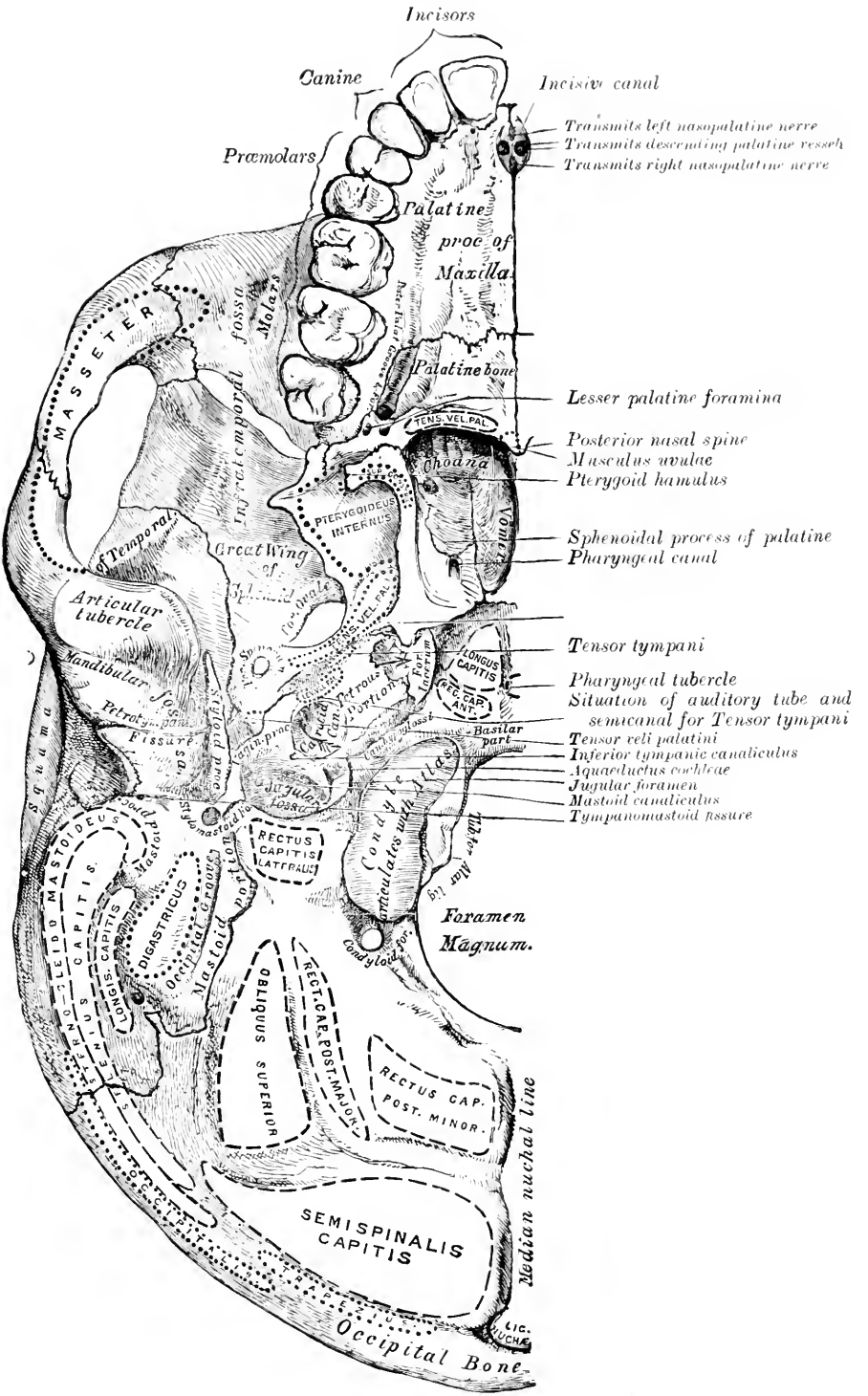


Fig. 2.—Base of the skull. Inner or cerebral surface. (Gray.)


Incisors
Canine
Incisive canal
Transmits left nasopalatine nerve
Transmits descending palatine vessels
Transmits right nasopalatine nerve
Præmolars
Palatine proc. of Maxilla
Palatine bone
Lesser palatine foramina
TENS. VEL. PAL.
Posterior nasal spine
Musculus uvulae
Choana
Pterygoid hamulus
PTERYGOIDEUS INTERNUS
Vomer
Sphenoidal process of palatine
Pharyngeal canal
MASSETER
Infratemporal fossa
Molars
Great Wing of Sphenoid
Articular tubercle
Mandibular fossa
Petrotympanic Fissure
Tensor tympani
LONGUS CAPITIS
Pharyngeal tubercle
Situation of auditory tube and semicanal for Tensor tympani
Basilar part
Tensor veli palatini
Inferior tympanic canaliculus
Aquaeductus cochleae
Jugular foramen
Mastoid canaliculus
Tympanomastoid fissure
Squama
Jugular fossa
Condyle articulates with Atlas
RECTUS CAPITIS LATERALIS
Tubter Alar lig.
Foramen Magnum.
Condyloid for.
STERNO CLEIDO MASTOIDEUS
STERNUS CAPITIS
LONGIS. CAPITIS
DIGASTRICUS
Occipital Groove
Mastoid portion
OBLIQUUS SUPERIOR
RECT. CAP. POST. MAJOR
RECTUS CAP. POST. MINOR.
Median nuchal line
SEMISPINALIS CAPITIS
Occipital Bone

The *external or inferior surface of the base* (Fig. 3) (the mandible removed) presents the following points for study: (*a*) In front is the hard palate bordered by the teeth. Behind the incisor teeth is a depression in the palate known as the *anterior palatine fossa*. In the floor of this fossa are four foramina for the passage of the naso-palatine nerves and bloodvessels from the nose. On the hard palate opposite the last molar teeth are the *posterior palatine foramina* transmitting the descending palatine arteries and the anterior palatine nerves to the hard palate. (*b*) Behind the hard palate are seen the posterior openings of the nasal cavities on the outer sides of which are the two pterygoid processes of the sphenoid bone. (*c*) External to these processes are the *zygomatic fossæ* which contain three of the large muscles of mastication, the inferior maxillary division of the fifth nerve and the internal maxillary artery. These fossæ communicate with the orbits by means of the large *sphenomaxillary fissures*. (*d*) Numerous foramina the most important of which are: ovale, external opening of the carotid canal, stylo-mastoid, posterior lacerated, condyloid and magnum. (*e*) Two pairs of articulating surfaces, the one to receive the condyles of the mandible and named the *glenoid fossæ*, the other to articulate with the first vertebra. (*f*) The styloid and mastoid processes which form pronounced landmarks and serve for the attachment of muscles.

The Lateral Aspect of the Skull (Fig. 1).—The following landmarks present themselves for study. (*a*) The malar bone that forms the prominence of the cheek. (*b*) The zygoma which lies very superficially and affords attachment to the masseter muscle. (*c*) The external auditory meatus and (*d*) the styloid and mastoid processes. It is of interest to note that practically all of the bone that enters into the formation of the side of the skull above the zygoma is covered by the largest of the muscles of mastication, *i. e.*, the temporal.

The Anterior Aspect of the Skull or Face.—The anterior portion of the skull is termed the face. The following fourteen bones enter into its make-up: two nasal, two lachrymal, the vomer, two superior maxillary, two malar, two inferior turbinates, two palate and the mandible. Passing from above downward the following points of interest are noted: (*a*) The supra-orbital foramina or notches through which pass arteries and nerves bearing the same names. (*b*) The orbits, in which well-protected cavities lie the eyes. (*c*) The nasal fossæ. (*d*) The infra-orbital foramina which transmit the infra-orbital arteries and the end-branches of the superior maxillary nerves. (*e*) The prominent malar bones. (*f*) The teeth of the upper and lower jaws supported by their alveolar processes. (*g*) The mental foramina through each of which an artery and nerve of the same name emerge. (*h*) The mandible or lower jaw.

The Orbits.—These are irregular, conical cavities, with the base toward the exterior and the apex inward. The outer edge of the base is in the form of a strong bony ridge which projects a little beyond the eye and thus protects it from injury. Seven bones enter into the

formation of the walls of the orbits. On the superior aspect of the outer wall near the base is a depression for the *lachrymal gland*. Each orbit is in communication with various other cavities and fossæ by means of the following openings: (*a*) The optic foramen and (*b*) sphenoidal fissure open into the middle fossa of the cranial cavity; (*c*) the sphenomaxillary fissure gives entrance into the sphenomaxillary and zygomatic fossæ; (*d*) on the inner wall, the anterior and posterior ethmoidal foramina, which transmit vessels of the same names and the former also the nasal nerve, lead into the anterior fossa; and (*e*) the nasal duct opens into the nose. The posterior opening of the infra-orbital canal is seen on the floor of the orbital cavity.

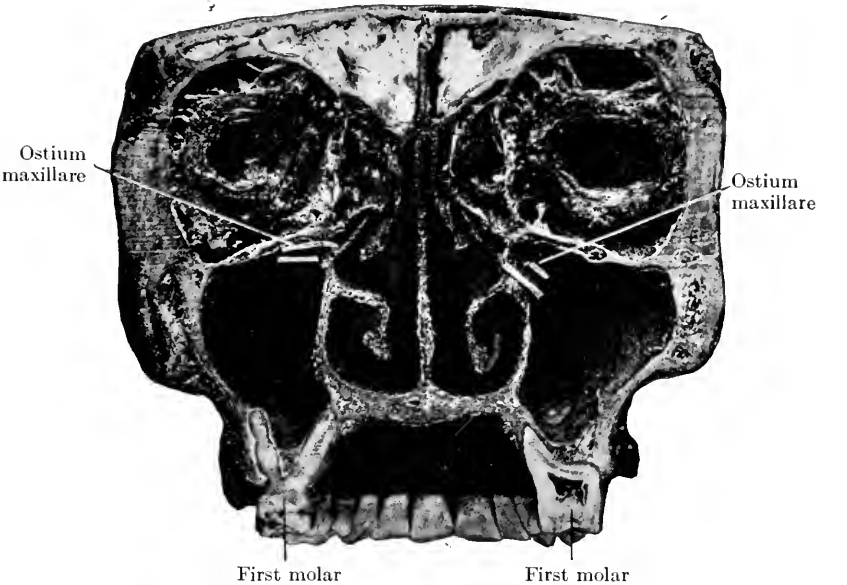


FIG. 4.—Vertical transverse section of typical skull. (Cryer.)

The Nasal Fossæ (Fig. 4).—These are large, irregular shaped cavities extending from the floor of the cranium to the roof of the mouth. They are separated from each other by a thin partition made up of bones and cartilage and called the *nasal septum*.

In front these fossæ communicate with the exterior by means of two large openings called the *anterior nares*. In back they open into the pharynx through the *posterior nares or choanæ*.

The lateral walls are very irregular and are divided by shelf-like bones named turbinates (scroll-like) into three or more sections called *meati*. The turbinate bones are normally three in number and according to their position receive the names of inferior, middle and superior.

The floor of the nose is formed by the same bones that make up the hard palate, *i. e.*, the palatal processes of the superior maxillary

and the horizontal processes of the palate bones. The superior surface of these processes receives the name, "floor of the nose," while the inferior surface is called the "roof of the mouth."

The nasal fossæ are in communication by means of openings and canals with the following cavities: (*a*) The cranium, (*b*) the orbits, (*c*) the pharynx, (*d*) the mouth, (*e*) three sinuses, *i. e.*, maxillary, frontal and sphenoidal, and (*f*) three sets of air cells, *i. e.*, anterior, middle and posterior ethmoidal.

According to function the nasal fossæ are divided into two parts, the olfactory and respiratory. The olfactory area is in the upper portion and extends down to include the middle turbinate bones on the one side and two-thirds of the septum on the other. The respiratory portion takes in the remainder of the cavity.

The nose is lined with mucous membrane which in the olfactory portion is non-ciliated but contains cells that are specialized to receive the sensations productive of smell. That in the respiratory portion is much thicker, contains large plexuses of veins and its cells are of the ciliated variety. Many glands are found in the mucous membrane of both portions of the nasal cavities. Their secretion is poured upon the free surface of the membrane keeping this moist. The inspired air is warmed as it passes over this membrane due to the heat imparted from the great amount of blood found in the large venous plexuses.

The *blood supply* to the nasal cavity comes through the internal maxillary, the ophthalmic and the facial arteries.

The *nerve supply* is of two kinds: (*a*) that of special sense through the first cranial or olfactory nerve and (*b*) that of common sensation through the fifth cranial or trifacial nerve.

The Bony Sinuses and Air Cells.—In all of the bones of the skull that have any great bulk we find cavities. The largest of these cavities are called sinuses while the smaller ones are called air cells. Their function is to reduce the weight of the bone and in the region of the mouth and nose to render the bone more resonant for the purpose of speech. The most important of these sinuses and air cells are the following:

Maxillary or Antra of Highmore.
Sphenoidal.
Frontal.
Anterior, Middle and Posterior Ethmoidal.
Mastoid.

The Maxillary Sinuses or Antra of Highmore (Fig. 4).—These are two in number, situated within the bodies of the superior maxillary bones, external to the nose and below the orbits. In shape they are somewhat pyramidal, with their bases directed toward the nose and the apices at the prominence of the cheek. They open into the middle meati of the nose at points known as the infundibula. The antra are often divided and partitioned by bony septa. They are lined with mucous membrane which is directly continuous with that of the nose

and is covered with ciliated epithelium. The mucous membrane also contains glands. Often the roots of the molar and bicuspid teeth form elevations on the floors of the sinuses and when diseased frequently infect the mucous membrane with most serious results.

The Sphenoidal Sinus (Fig. 5). This air cavity may be a single one but is usually partitioned into two distinct cells. It is situated within

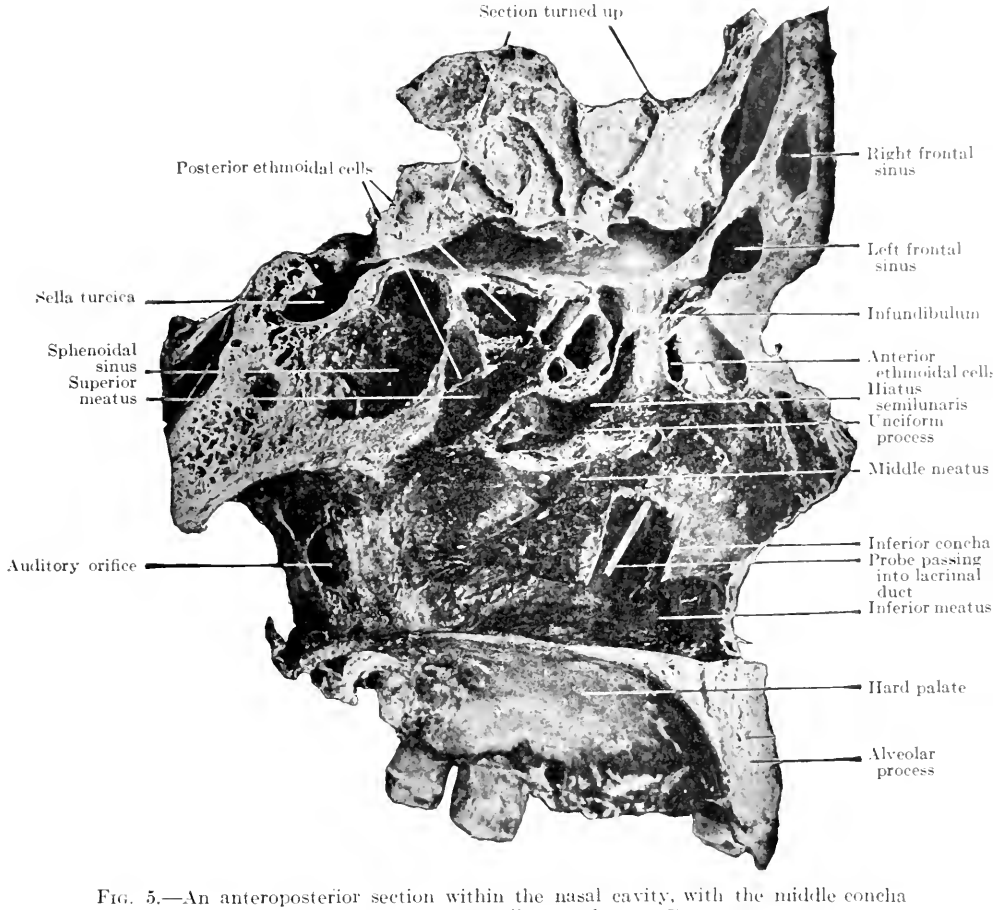


FIG. 5.—An anteroposterior section within the nasal cavity, with the middle concha and portion of the cell walls turned up. (Cryer.)

the body of the sphenoid bone at the posterior aspect of the roof of the nose. It has an opening into the superior meatus and is also lined with mucous membrane continuous with that of the nasal cavity. Often the posterior ethmoidal air cells communicate with this sinus.

The Frontal Sinuses (Fig. 5).—These are two fairly large cavities within the frontal bone. They are located immediately above the orbits and their position is marked approximately by the eyebrows.

They are really a continuation of the anterior ethmoidal air cells of their respective sides. They open into the middle meati of the nose. Congestion of these sinuses is a usual sequence in a so-called "cold in the head," and gives rise to the accompanying headache so frequently noted in this condition.

The Ethmoidal Air Cells (Fig. 5).—There are three sets of these found within the lateral masses of the ethmoid bone and named according to their position, anterior, middle and posterior. They are lined with mucous membrane which is a continuation of that lining the nasal passages into which each set of cells opens. These cells are often interconnected and frequently the posterior set communicates with the sphenoidal sinus.

The orifices of the canals that lead from the nose to the anterior ethmoidal cells are intimately associated with the openings into the antra and into the frontal sinuses. Thus it is that the antrum, the anterior ethmoidal cells and the frontal sinus of each side are made intercommunicating and their mucous membrane linings practically continuous with each other. These anatomical facts make it very possible for an infection arising within one cavity to travel to one or both of the others. Cases are not uncommon in which an abscess on the root of an upper molar or bicuspid tooth infects the mucous membrane of the antrum and the discharge from this tissue passing into the nose infects the lining membrane of the canal that leads to the anterior ethmoidal air cells. The infection traveling up this canal will eventually involve these cells. The mucous membrane of the frontal sinus may also become involved from the same source, either by an extension from the nasal mucous membrane or directly from that of the anterior ethmoidal cells. Such a pathological condition may be continued into the middle and posterior ethmoidal cells and the sphenoidal sinus.

The mastoid air cells or antra are situated within the mastoid portion of the temporal bones and will be mentioned under the description of the ear.

THE EYES.

These are the organs of vision and consist of two globular bodies situated within the orbits. They are freely movable by means of a ball-and-socket joint formed between the eyeball and a tough, fibrous membrane arranged in the form of a socket. This membrane receives the name of the *capsule of Tenon*. Movement of the eyeball is performed through the agency of six muscles that arise from the bony wall of the orbit and are attached to the ball at various points.

The anterior portion of the eye is covered with a modified mucous membrane which is reflected on to the lids and lines the inner side of these. This membrane is called the *conjunctiva* and covers that portion of the eye that is commonly called the "white."

The eyeball (Fig. 6) is made up of three coats within which are three refracting media. The *coats* are named:

1. Outer or fibrous.
2. Middle or vascular.
3. Inner or nervous.

The *refracting media* are:

1. Aqueous humor.
2. Crystalline lens.
3. Vitreous humor.

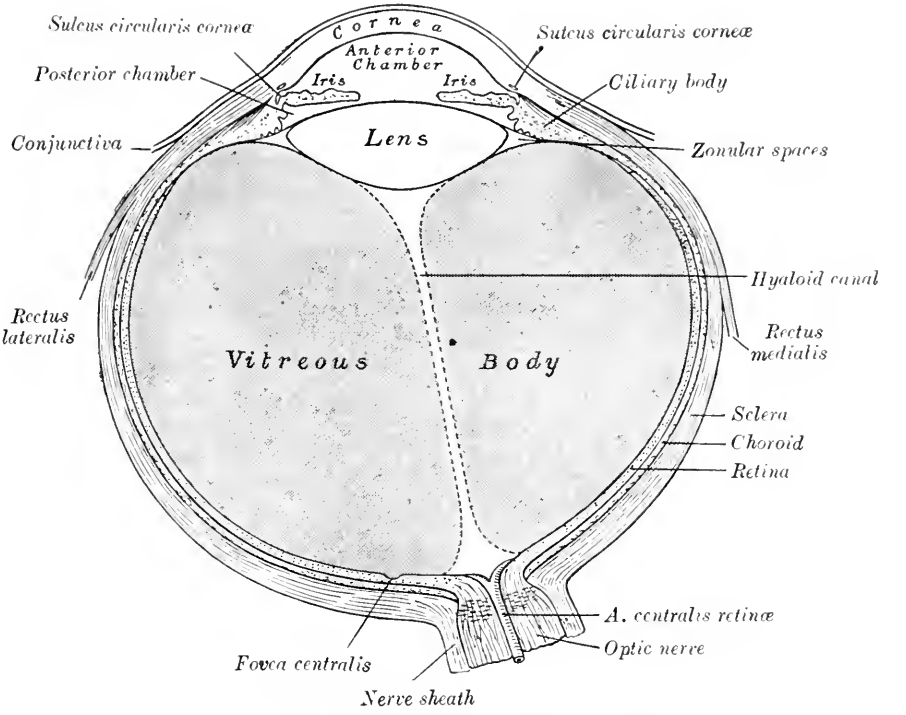


FIG. 6.—The right eye in horizontal section. (Toldt.)

The Coats of the Eye.—*Fibrous Coat.*—This is divided into two parts: (*a*) Cornea, forming the anterior sixth of the sphere and (*b*) the sclera, forming the remainder. (*a*) The Cornea. This tissue is made up of cells that will transmit the rays of light and so may be likened to a window. It is more highly convex than the rest of the eyeball, giving this portion of the ball a bulging appearance. Its posterior edge is continued into the sclera. (*b*) The Sclera. This is a firm, inelastic, fibrous membrane forming the posterior five-sixths of the eyeball.

Vascular Coat.—This is divided into three parts:

The iris.
The ciliary body.
The choroid.

(*a*) The *iris* may be likened unto a circular curtain attached at the periphery and perforated in the center. This "hole" in the center is called the *pupil*. The iris contains pigment of varying tint and is the tissue that gives the color to the eye. In structure it consists for the most part of muscular fibers of two kinds, circular and radiating. When the circular contract the pupil becomes smaller and when the radiating are active the pupil enlarges.

The iris is suspended in a cavity formed by the cornea in front and the lens behind. It is nearly in contact with the latter structure. This cavity is filled with a modified lymph called the *aqueous humor*.

(*b*) The *ciliary body* is made up of the ciliary processes and the ciliary muscle. The *ciliary processes* are composed of foldings, as it were, of the tissues making up the middle coat and are continuous at their posterior ends with the choroid and at their anterior ends with the suspensory ligament of the lens and the iris. They vary from sixty to eighty in number. The *ciliary muscle* is arranged in the form of a circular band of involuntary muscle fibers lying on the outer surface of the middle coat of the eye between the iris and the choroid. Its function is to control the convexity of the lens so that the rays of light may be properly focused. The ciliary body is an exceedingly vascular area and consequently is very liable to be the seat of an infection, hence it has been designated as the "danger area" of the eye.

(*c*) The *choroid* is that portion of the middle coat that lies posterior to the ciliary body. It is made up of areolar tissue, bloodvessels, and considerable pigment.

Nervous Coat.—This is commonly called the *retina*. It is continuous with the optic nerve behind and extends forward about as far as the ciliary body where it ends in a jagged margin. It may be called the end-organ of the optic nerve with the special sense of vision as its function.

The fibers of the optic nerve are distributed to all parts of this membrane and end in physiological relationship with special cells, *the rods and cones*, of the neuro-epithelium lining the retina. The rods and cones receive the visual impressions and transfer them to the nerve fibers.

In examining the retina a white circular area is noted at the point of entrance of the optic nerve. This is called the *optic disc* and is the one point on the membrane where the rays of light will make no impression. In other words, it is a blind spot. For this reason it is located eccentrically so that the same rays of light will not be received on a blind spot in each eye, damaging the field of vision. Its position is somewhat to the inner side of the center. Directly in the center of the retina is the area where the most acute vision is to be had. This is called the *macula lutea* (yellow spot) because of its color. In the center of this is a depression known as the *fovea centralis*.

The Interior of the Eyeball.—The interior of the eyeball is unequally divided by the lens. That portion in front of the lens is further sub-

divided by the iris into two compartments known as the anterior and posterior chambers. The anterior chamber communicates with the posterior chamber through the pupil.

The Refracting Media.—The Aqueous Humor. This is a watery fluid filling the anterior and posterior chambers of the eye. It is derived from the vessels within the ciliary body and any excess is carried off through spaces and canals that empty into the ciliary veins.

The Crystalline Lens.—This is a biconvex, circular body made up of transparent fibrous tissue the component parts of which are cemented together with a transparent cement substance and the entire mass of tissue is surrounded by a capsule. It lies in a depression on the anterior surface of the vitreous body and is held in position by the *suspensory ligament of the lens*. The function of the lens is to bring the rays of light to a proper focus upon the retina.

The Vitreous Humor or Body.—In contact with the retina and filling the interior of the eyeball behind the lens is the vitreous humor. It is composed of a soft, jelly-like substance, perfectly transparent, and made up of semisolid connective tissue. This is surrounded by a membrane that is thickened anteriorly to form the *suspensory ligament of the lens* which holds the lens in position and affords attachment to the ciliary processes. The anterior surface of the vitreous body presents a cup-like depression into which the lens fits.

The Lachrymal Apparatus.—This consists of (*a*) the *lachrymal* or *tear gland* which is situated in a depression at the outer angle of the orbit at its upper aspect and from which several ducts lead and open through the conjunctiva of the upper lid just before this is reflected on to the eyeball; (*b*) the *lachrymal sac*, placed at the inner angle of the orbit and gathering in the tears by means of two small canals leading from the inner corner of each lid; and (*c*) the *nasal duct*, a passage that leads from the sac to the inferior meatus of the nose and discharges its contents into this cavity.

THE EARS.

The organ of hearing (Fig. 7) is divided into three portions:

1. The external ear.
2. The middle ear.
3. The internal ear or labyrinth.

The External Ear.—This consists of the cartilaginous structure that is commonly called the "ear" and the external portion of the auditory canal. The latter, known as the *external auditory canal*, is about one inch in length and runs inward and somewhat forward. It is separated from the middle ear by the tympanic membrane or drum. Its external opening is termed the *external auditory meatus*.

The Middle Ear.—This extends from the drum to the internal ear. It approximates one-sixth of an inch in length and is nearly one-half an inch in its vertical diameter. In this cavity are the three ear bones

or ossicles, as they are called. The middle ear is in communication with the mastoid antrum through a small opening and with the nasopharynx *via* the Eustachian tube. Through the middle ear, embedded in its mucous membrane lining, passes the chorda tympani nerve, a branch of the facial, on its way to join the lingual branch of the mandibular nerve. As will be noted later, this nerve transfers the special sensations of taste from the anterior portion of the tongue to the brain. Hence disease of the middle ear may be attended with loss of the sense of taste on the corresponding side of the tongue owing to involvement of this nerve.

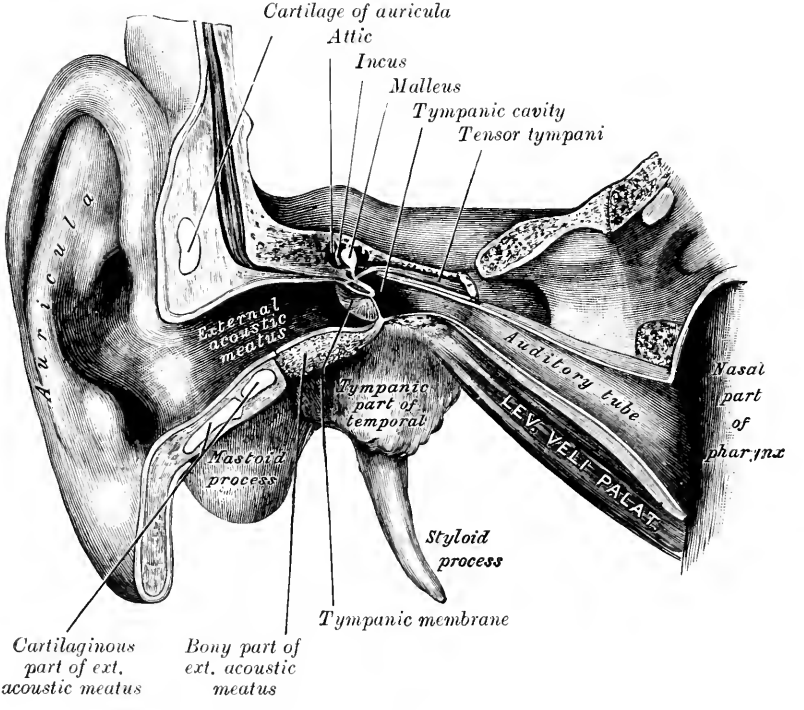


FIG. 7.—External and middle ear, opened from the front. Right side. (Gray.)

The Tympanic Membrane or Drum.—This consists of an oval membrane, obliquely attached to the sides of the auditory canal, the upper portion being nearer the external opening. It presents a concave surface to the exterior. Between its layers is bound the "handle" of the malleus, one of the ossicles.

The Ear Ossicles.—These are three in number and are named from without inward, the malleus or hammer, the incus or anvil and the stapes or stirrup: (*a*) The malleus is bound to the drum by means of its handle while its so-called head articulates with the body of the incus. (*b*) The incus is shaped very much like a lower molar tooth in that it has two root-like processes projecting from a body. The body

articulates with the malleus and the longer of the processes with the stapes. (*c*) The stapes on the one hand articulates with the incus and on the other fits into the oval window located on the wall of the internal ear. These bones are held in position by ligaments that are attached to the wall of the middle ear. The *function* of the ear ossicles is to transmit and magnify the sound waves received by the tympanic membrane, conveying them to the lymph contained within the internal ear.

The Mastoid Antrum.—This consists of a moderately large cavity and several smaller ones, situated within the mastoid portion of the temporal bone just behind the middle ear and in communication with it. These air cavities are often the seat of infection.

The Eustachian Tube.—This canal begins at the anterior end of the middle-ear cavity, passes downward, forward and somewhat inward to the nasopharynx. It is about an inch and a half in length. The *function* of the Eustachian tube is to keep the air within the middle ear of the same density as that of the exterior. This prevents any damage to the drum arising from inequality of air pressure.

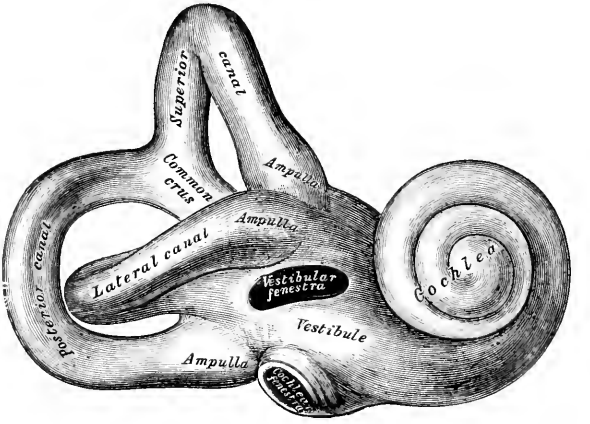


FIG. 8.—Right osseous labyrinth. Lateral view. (Gray.)

The Internal Ear or Labyrinth (Fig. 8).—This consists of three parts:

The vestibule.

The cochlea.

The semicircular canals.

Each one of these parts is made up of bony walls enclosing within them a membraneous structure. Separating the membraneous portion from the bony is lymph which receives the name of *perilymph*, while within the membraneous structures is more lymph, termed *endolymph*.

Of the three parts of the internal ear, the cochlea is placed anteriorly and the semicircular canals posteriorly, while the vestibule lies between them and serves as a connecting chamber.

The Vestibule.—In the external wall of the vestibule is the oval window into which, as already stated, fits the base of the stapes. The vestibule opens into the cochlea by one opening and into the semicircular canals by five openings. It contains two membraneous, sac-like structures, the *utricle* and the *saccule*. These are filled with endolymph and are connected with the membraneous portions of the semicircular canals and cochlea. In the utricle are also found many minute calcareous bodies called *otoliths*. These, by shifting their positions under varying conditions, transmit impulses to the nerve filaments in the mucous membrane of the utricle.

The Cochlea.—This in structure resembles a snail's shell and from the exterior is somewhat cone-shaped. It is placed with the apex outward. In its base are found numerous openings through which the branches of the auditory nerve pass. The base measures about two-fifths of an inch in diameter and the height of the structure is approximately one-quarter of an inch. The spiral canal within the cochlea makes about two and a half turns around the central axis. This canal is divided into three compartments running the whole length of the spirals. In the median compartment, which is the membraneous portion of the cochlea, is the *organ of Corti*, the name given the structure which receives the sound waves and transmits them to the filaments of the auditory nerve ending within the mucous membrane lining. This compartment is filled with endolymph.

The Semicircular Canals.—These are three in number and come off from the posterior aspect of the vestibule. They are so located as to be at right angles with one another. Two are in the vertical plane and one in the horizontal. Within these are the membraneous semicircular canals, external to which is the perilymph and within which is the endolymph. They are lined with a special form of epithelium, the cells of which are in intimate relationship with the end filaments of the vestibular branches of the auditory nerve. These canals undoubtedly play an important part in the mechanism concerned in the maintenance of the equilibrium of the body.

Interconnection of the Nerve Supply of the Ears and Teeth.—The nerves to the ears are associated, through certain ganglia, *i. e.*, the otic and Meckel's, with the nerves that supply the teeth. Hence it is not uncommon to have earache accompanied by toothache or *vice versa*. At times earache may be the only symptom of a dental lesion.

THE MOUTH.

The mouth may be defined as the cavity at the beginning of the alimentary canal. It contains the organ of mastication and is intimately connected with the function of speech and the special sense of taste. It is bounded in *front* by the lips; *laterally* by the cheeks; *above* by the hard and soft palates; and *below* by the mylohyoid and genio-hyoid muscles which form its floor. It contains the teeth and the tongue.

Anteriorly the mouth opens to the exterior through the lips and posteriorly into the pharynx through the *fauces*. The mouth cavity is divided into two portions: (*a*) the vestibule, which lies between the lips, cheeks and teeth, and (*b*) the mouth proper or oral cavity, internal to the teeth. It is lined with mucous membrane of the stratified squamous variety. This membrane contains many mucous glands which pour their contents into the mouth.

The bony framework of the mouth is formed by (*a*) the superior maxillary bones, (*b*) the palate bones, and (*c*) the inferior maxillary bone or mandible.

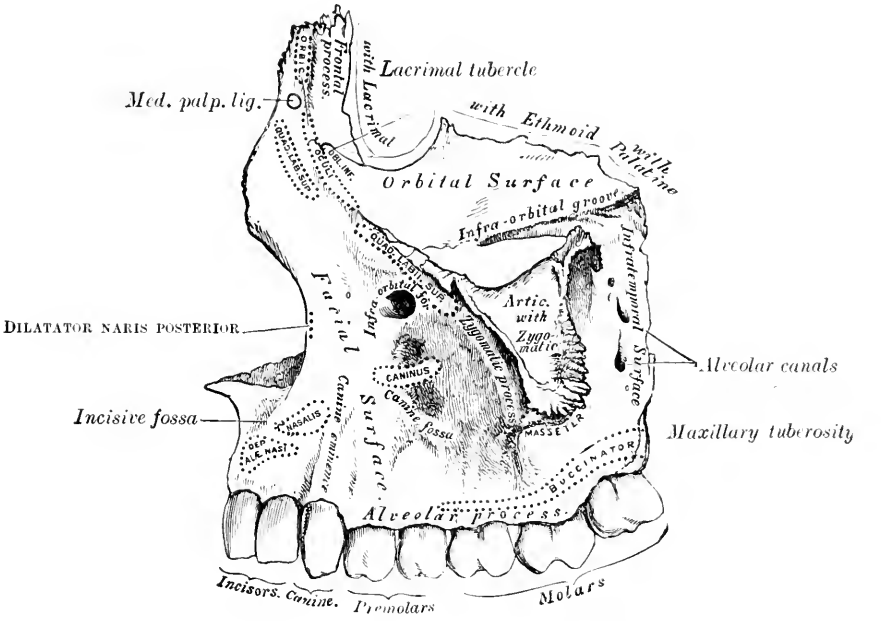


FIG. 9.—Left maxilla. Outer surface. (Gray.)

The Superior Maxillary Bones (Fig. 9).—These are two in number and form the bulk of bone below the forehead exclusive of the prominences of the cheeks. Each superior maxilla consists of a *body* and *four processes*.

The Body.—On the *anterior surface* is seen, from above downward: (*a*) a portion of the orbital margin; (*b*) the infra-orbital foramen; (*c*) incisive fossa, a depression above the roots of the incisor teeth; (*d*) the canine fossa, a depression behind the prominent root of the cuspid tooth, and (*e*) the ridges of bone overlying the roots of the incisor and cuspid teeth; (*f*) in the median line a sharp process of bone called the nasal spine.

The *superior surface* of the body forms a portion of the floor of

the orbit. It presents the inner opening of the infra-orbital canal. From this canal are given off branch canals which convey the blood-vessels and nerves to the anterior teeth and bicuspids.

The *posterior surface* forms part of the zygomatic fossa and presents the opening of the posterior dental canals that take the blood-vessels and nerves to the molar teeth.

The *internal or nasal surface* forms a portion of the outer wall of the nasal cavity. It presents the opening that leads into the maxillary sinus or antrum of Highmore. This large air cavity is situated within the body of the superior maxillary bone and has been described under the heading of Sinuses.

The Four Processes:

1. Nasal.
2. Malar.
3. Palate.
4. Alveolar.

The *nasal process* is situated between the nose and the orbit, projecting upward from the body of the bone and articulates with the frontal bone.

The *malar process* manifests itself on the outer surface of the bone and articulates with the malar bone.

The *palate process* projects horizontally from the inner surface of the body, articulates with the corresponding process of the superior maxillary bone of the opposite side and thus forms with its superior surface the anterior portion of the floor of the nose and with its inferior surface, the corresponding portion of the roof of the mouth.

The *alveolar process* is built up on the lower, outer border of the body for the purpose of supporting the teeth, the roots of which are found within its substance.

The Palate Bones (Fig. 10).—These are two in number. In form they may be likened to the letter "L". Their upright portion, called the vertical plate, helps to form the outer wall of the nasal cavity. The bone corresponding to the base of the "L" is called the horizontal plate and articulates anteriorly with the palate process of the superior maxilla, thus aiding in the formation of the floor of the nose and roof of the mouth. Posteriorly the horizontal plate ends in a free border to which is attached the soft palate.

The Inferior Maxillary Bone or Mandible (Fig. 11).—In form this bone resembles a horseshoe and is composed of a *body* and two *rami*. The latter arise from the posterior ends of the body. The angle formed between the rami and the body varies in degree according to race, type and age. The mandible is the only bone in the skull that is movable.

The Body.—The *external surface* is usually concave from above downward, and ends below in a thick ridge. In the median line in front is another thick ridge placed at right angles to the border. This

receives the name of *symphysis menti*. Below, this fuses with the lower border of the bone to form the prominence of the chin.

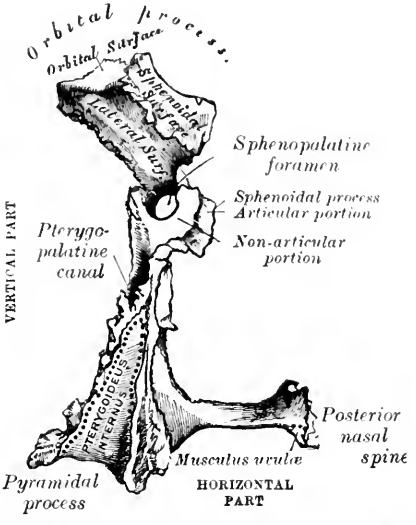


FIG. 10.—Left palatine bone. Posterior aspect. Enlarged. (Gray.)

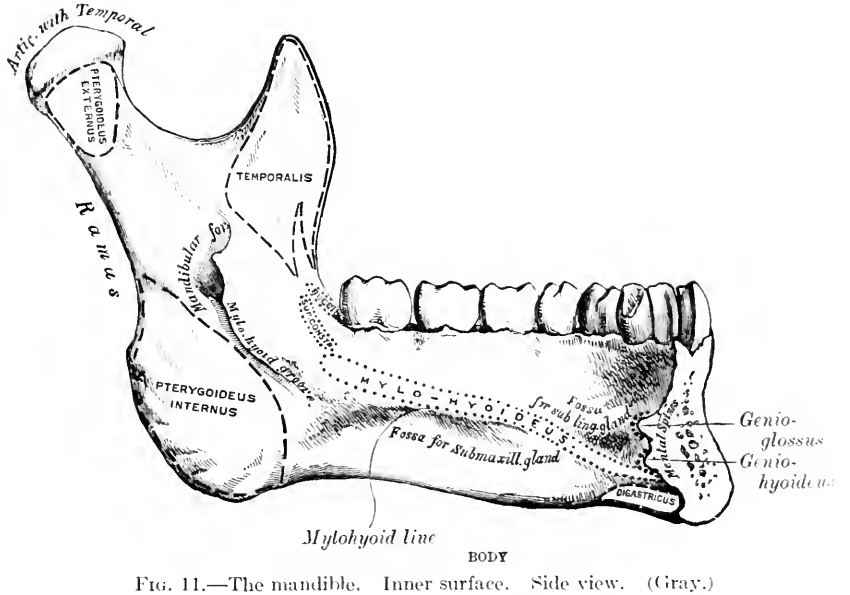


FIG. 11.—The mandible. Inner surface. Side view. (Gray.)

In the region of the first and second bicuspid teeth and about half-way between the upper and lower borders of the bone are seen the *mental foramina*, one on either side. These are the anterior open-

ings of the mandibular canals and transmit the mental vessels and nerves. The *alveolar process* is built on the superior border of the body and serves to maintain the lower teeth in position.

The *internal surface* (Fig. 11) presents in the median line *four tubercles* for the attachment of muscles. Passing back from these along the body of the bone and half-way between its borders is a ridge called the *mylohyoid ridge*. This serves for the attachment of the muscle of the same name which forms the floor of the mouth. Above this ridge just to either side of the median line are two depressions called the *sublingual fossæ* and resting in these lie the *sublingual glands*. Below this ridge in the region of the bicuspid and molar teeth on either side, are two other depressions that receive the *submaxillary glands*. The sublingual and submaxillary glands pour their secretion into the mouth through a common duct, Wharton's, the opening of which is on either side of the frenum of the tongue.

The Rami.—The *external surface* of each ramus serves for the attachment of one of the muscles of mastication, the masseter. The *posterior border* terminates below in what is commonly called the angle of the jaw. The *internal surface* serves as a place of attachment for certain of the muscles of mastication, *i. e.*, the internal pterygoid and the temporal. This surface presents about at its midpoint an opening, the *inferior dental foramen*, which leads into the canal of the same name. It transmits the inferior dental artery and nerve which furnish the blood and nerve supply to the lower teeth.

The *superior border* of each ramus presents two prominences between which is a well-marked notch. The anterior prominence is called the *coronoid process* and serves for the attachment of the temporal muscle. The posterior prominence is surmounted with an articular cartilage, receives the name of the *condyle*, and enters into the formation of the temporomaxillary articulation. To the internal surface of the condyle is attached the external pterygoid muscle.

The Temporomaxillary Articulation.—This is a sliding hinge joint and is formed by the glenoid fossa on the base of the skull and the condyle of the mandible. The glenoid fossa is somewhat cup-shaped and is limited anteriorly by a ridge, the *eminentia articularis*. This aids the ligaments of the joint in restricting the forward slide of the mandible. The articulating surface of the condyle is oblong with the long diameter in the transverse plane. Lying between the condyle and the fossa is the intra-articular fibro-cartilage. The capsular ligament encloses the entire joint in a fibrous sheath. Four strong fibrous ligaments help to maintain the proper position of the condyle.

The Muscles Active in Moving the Mandible.—These may be divided into two sets: (*a*) the so-called "muscles of mastication" which bring the lower teeth in contact with the upper in the process of chewing by raising the mandible and (*b*) the depressor muscles or those which pull the mandible downward as in opening the mouth.

(*a*) The *muscles of mastication* are five in number, *i. e.*:
Temporal.
Masseter.
Buccinator.
Internal pterygoid.
External pterygoid.

(*b*) The depressor muscles are also five in number.
Genio-hyoid.
Genio-hyo-glossus.
Mylo-hyoid.
Digastric.
Platysma myoides.

The Lips and the Cheeks (Fig. 12).—These structure are made up of muscles and fibro-elastic tissue. By the action of the muscles found in the lips and cheeks are produced the many varied facial expressions giving the outward manifestation of different mental states. Hence these muscles are known as the *muscles of expression*. The lips and cheeks are covered on the external surface with skin and on their internal or oral surface with mucous membrane. These two coverings unite at the outer border of the lips. The mucous membrane contains many mucous glands which pour their secretion into the mouth cavity. In the center of the upper lip and sometimes of the lower a fold of mucous membrane is reflected onto the alveolar process. This is called the *frenum*.

On the inside of the cheek about opposite the upper second molar tooth is seen a small papilla which marks the opening of the duct leading from the parotid gland.

The Hard Palate.—The hard palate is formed by the palate processes of the superior maxillary bones and the horizontal processes of the palate bones. Posteriorly it ends in a free border to which the soft palate is attached. It is covered with mucous membrane the surface of which anteriorly is thrown into folds, called *rugæ*.

The Soft Palate.—This structure is attached to the posterior border of the hard palate and is formed by five different muscles. These are in turn covered with mucous membrane. The function of this structure is to shut off the nasal passage from the mouth during the act of swallowing.

The Mucous Membrane.—The mucous membrane or lining tissue of the mouth is made up of two layers, the epithelium and the underlying connective tissue on which this rests. Beneath these two layers is the *submucosa* which is also composed of connective tissue.

The epithelium is of the stratified squamous variety the outer cells of which become cornified and scaly on that part overlying the alveolar process and the hard palate (Fig. 13). Under the epithelium is a layer of fibro-elastic tissue the outer surface of which is surmounted with papillæ that extend into the epithelium. In this tissue may be seen the ducts of many glands which are passing through the mucous membrane to

reach the free surface. The glands themselves are located in the submucosa which is composed of large bundles of white fibrous connective tissue, ably supporting the mucous membrane and richly supplied with bloodvessels and nerves. The glands are of two varieties, serous and mucous, and they are constantly active.

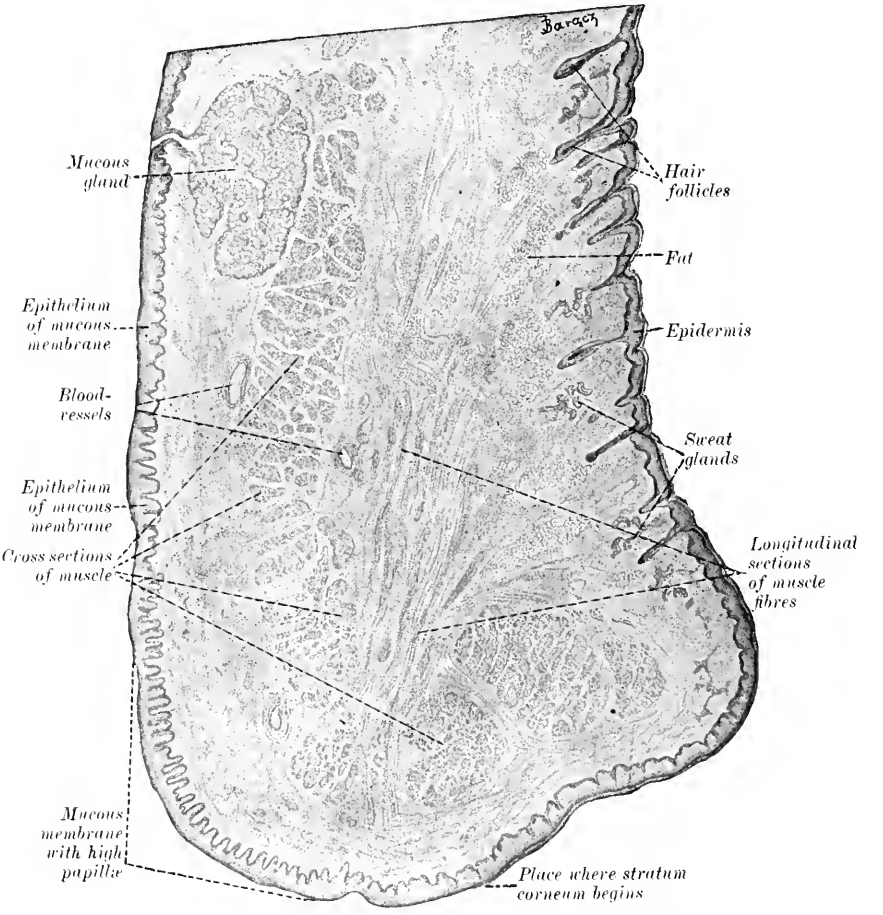


FIG. 12.—Section through the upper lip of a two-and-a-half-year-old child. × 14. (Szymonowicz.)

The Tongue.—The tongue is a muscular organ composed of a *root*, *a body* and an anterior free extremity or *tip*. It is made up of five muscles and is covered with mucous membrane. The under surface is attached to the floor of the mouth by a fold of this membrane called the frenum. The base of the tongue is attached to the hyoid bone and to the muscles of the pharynx.

On the surface of the tongue are seen three varieties of *papillæ*. These are composed of a connective-tissue core developed in the corium (tissue under the epithelium) and covered with epithelium.

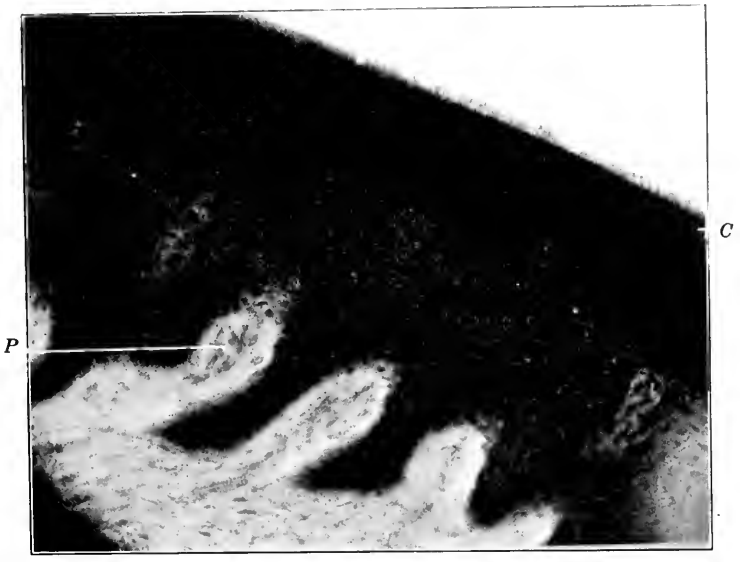


FIG. 13.—Stratified squamous epithelium covering the alveolar process: *C*, corneous layer; *P*, papilla of connective tissue. About 400 ×. (Noyes.)

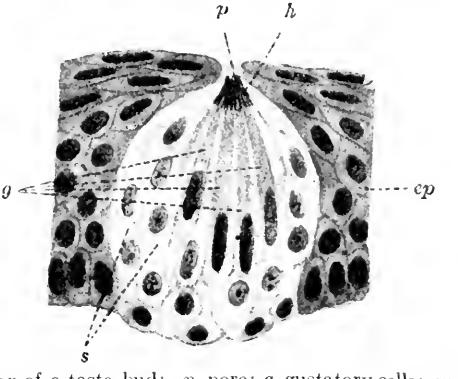


FIG. 14.—A section of a taste bud: *p*, pore; *g*, gustatory cells; *ep*, epithelial cells; *s*, sustentacular cells; *h*, bristles of the gustatory cells. (Schaefer.)

The most important of these papillæ are situated on the back part of the tongue, are arranged in the form of a "V" with the point backward, are eight to twelve in number and are called *circumvallate papillæ*. At the base of these papillæ are located the *taste buds* (Fig. 14),

specialized bodies in which filaments of the glossopharyngeal nerve end and through which media the sense of taste is active. Probably there are also some taste buds in the anterior portion of the tongue which are innervated by branches from the chorda tympani nerve that reaches the tongue by joining the lingual nerve soon after it branches from the mandibular nerve.

On the base of the tongue, behind the circumvallate papillæ, is found considerable lymphoid tissue. This is given the name of the *lingual tonsil.*

The nerve supply of the tongue is interesting in that it is derived from four different sources. The four nerves functionate in three ways: (*a*) The nerves of special sense are the glossopharyngeal and the chorda tympani. (*b*) The nerve of common sensation is the fifth cranial or trifacial and (*c*) the motor nerve to the muscles of this organ is the hypoglossal or twelfth cranial.

The Nerve and Blood Supply of the Dental Tissues.—The *nerve supply* to the structures entering into the formation of and associated with the oral cavity is mainly through the trifacial or fifth cranial nerves and the facial or seventh cranial nerves. Their *blood supply* is brought by the internal maxillary artery, a branch of the external carotid artery.

The Trifacial or Fifth Cranial Nerve (Plate I).—This is the great *sensory nerve* of the head and face. It also contains a few motor fibers. Its connections and terminations within the brain substance are very extensive and far too intricate to be detailed in a work of this kind. With its external distribution, however, the student is expected to be quite familiar. It must be borne in mind that while the fibers of the nerve are described anatomically as running from the brain to the periphery, yet physiologically, sensory nerves should be traced in just the opposite direction because they carry impulses from the exterior to the centrally located ganglia.

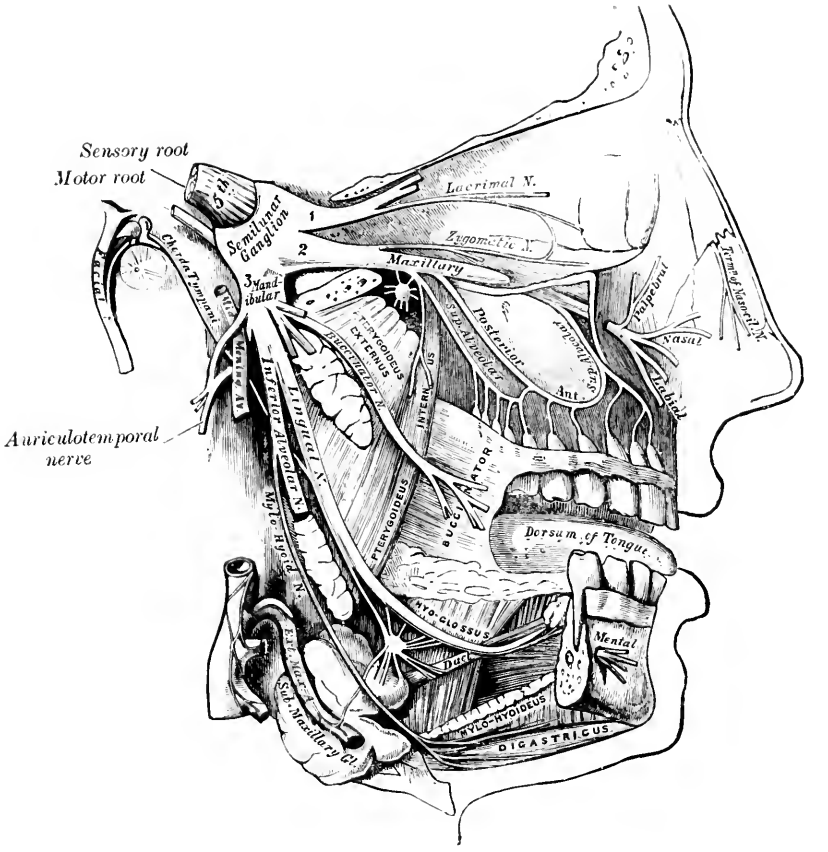
The fifth nerve leaves the pons Varolii (a portion of the spinal cord just below the brain) in the form of two roots, an anterior motor and a posterior sensory. The latter root enters a large ganglion, the Gasserian, situated on the floor of the middle fossa of the skull just behind the foramen ovale. From this ganglion three large trunks are given off as follows:

The ophthalmic or first division.
The superior maxillary or second division.
The inferior maxillary or third division.

The *ophthalmic division* passes forward and enters the orbit through the sphenoidal fissure supplying the various structures in this cavity, the nasal cavity and the upper part of the face, with sensation.

The *superior maxillary division* leaves the cranium through the foramen rotundum entering the sphenomaxillary fossa. From this fossa it gains entrance to the orbit *via* the sphenomaxillary fissure. It passes along the floor of the orbit to the infra-orbital canal which

PLATE I



Distribution of the Maxillary and Mandibular Nerves, and the Submaxillary Ganglion. (Gray).

it enters and then emerges from the canal through the infra-orbital foramen to supply the tissues of the face in the region of this opening. Just before this division enters the orbit it gives off the posterior superior dental branches that supply the upper molar teeth. These reach the teeth by passing through the posterior dental canals, the entrance to which are found on the posterior surface of the superior maxillary bones. While in the infra-orbital canal branches are given off that supply the upper bicuspid, cuspid and incisor teeth.

The other most important branches of the superior maxillary division are the sphenopalatine nerves which are given off in the sphenomaxillary fossa. These pass to a ganglion also situated in this fossa known as the sphenopalatine or Meckel's ganglion. They constitute the sensory roots of this structure. It also receives a motor root that comes indirectly from the facial nerve. Meckel's ganglion is of importance to the student of oral anatomy because its branches, which are numerous, are distributed to the mucous membrane of the sphenoidal and ethmoidal air cells and nasal cavity, to the hard palate, the soft palate and the tonsils.

There are no motor fibers found in either the ophthalmic or superior maxillary divisions of the fifth nerve. Their function is purely a sensory one, that of touch and pain, to those structures to which they are distributed.

The inferior maxillary division emerges from the cranium through the foramen ovale. Accompanying it through this opening is the motor root of the nerve which joins the sensory division just outside the cranium. This combined trunk is now located in the zygomatic fossa and almost immediately is found to divide again. One of these divisions contains nearly all of the motor fibers and is distributed to the muscles of mastication, excluding the buccinator. The other, containing but a few motor fibers and made up mostly of sensory ones, is the larger of the two and divides into three branches, *i. e.*, (*a*) the auriculotemporal, which supplies the tissue about the ear, the temporomandibular articulation and sends communicating branches to the facial (seventh cranial) nerve; (*b*) the lingual which, as previously stated, supplies common sensation to the tongue and which is joined by the chorda tympani branch of the facial nerve; and (*c*) the inferior dental nerve. This last branch enters the mandibular canal in the body of the inferior maxillary bone, traverses its entire length and emerges through the mental foramen as the mental nerve to supply sensation to the surrounding tissues. While in the mandibular canal minute branches are given off to the various lower teeth.

Just as the inferior dental nerve is about to enter the mandibular canal it gives off quite a large branch, the mylohyoid nerve. This contains motor fibers and passes downward to supply the mylohyoid and digastric muscles.

The inferior dental nerve also sends branches to two ganglia, the otic and the submaxillary, furnishing them with their sensory roots. The

most important nerves coming from these ganglia are secretory branches to the salivary glands.

The Facial or Seventh Cranial Nerve.—This is the great *motor nerve* of the head and face. It supplies the muscles of expression, certain of the ear muscles, one of the muscles of mastication, the buccinator, and sends communicating branches to three important ganglia, *i. e.*, the otic, the submaxillary and Meckel's.

The facial nerve also contains a few sensory fibers that convey taste sensation from the anterior two-thirds of the tongue.

The *facial nerve* emerges from the pons Varolii and enters the internal auditory meatus accompanying the auditory nerve and artery. It soon leaves the auditory canal and enters another bony canal known as the aqueductus Fallopii and comes out on the exterior of the skull through the stylomastoid foramen. It then enters the substance of the parotid gland and breaks up within this structure into a large terminal arborization known as the pes anserinus (duck's foot).

An important ganglion is situated on the facial nerve within the aqueductus Fallopii known as the geniculate ganglion. From this particular part of the nerve important branches are given off that communicate with Meckel's ganglion, the otic and submaxillary ganglia and the tympanic plexus of nerves, thus connecting the seventh nerve with the fifth and ninth cranial nerves. This fact is brought out that the student may realize how closely related and how intimately interconnected are the various parts of the cranial anatomy. Thus symptoms manifested in one area may be but transferred sensations from lesions in quite remote parts.

One of the most important branches of the facial nerve is the *chordi tympani* (Plate I). This is given off in the aqueductus Fallopii and contains mostly sensory fibers. It passes through the middle ear, lying on the tympanic membrane under the mucous membrane, and then escapes from this cavity through a small canal, entering the pterygo-maxillary region. It passes downward and forward to join the lingual branch of the inferior dental nerve. Its sensory fibers pass in this nerve to the tongue and supply its anterior two-thirds with taste sensation. The motor fibers contained in the chorda tympani are passed into the otic and submaxillary ganglia. They are probably the source of the secretory branches given off from these ganglia and going to the salivary glands.

After the facial nerve leaves the stylomastoid foramen branches are given off to muscles attached to the temporal bone near the styloid process and about the external auditory meatus. The branches forming the terminal arborization supply the muscles of expression situated about the eyes, nose, and the upper and lower lips. One of these branches also supplies the buccinator muscle.

The Internal Maxillary Artery.—This is one of the terminal branches of the external carotid artery and arises from that vessel at a point just below and internal to the condyle of the mandible. It embeds

itself deeply in the substance of the parotid gland, passes internal to the ramus of the jaw, through the zygomatic fossa to the sphenomaxillary fossa. From here it is continued as the sphenopalatine artery which passes into the nasal cavity through the sphenopalatine foramen.

Important Branches of the Internal Maxillary Artery.—Soon after its origin from the external carotid, the internal maxillary artery gives off (*a*) the middle meningeal artery, which is its largest branch. This passes upward and enters the cranial cavity through the foramen spinosum and supplies the whole of the dura mater with blood; (*b*) the mandibular or inferior dental artery, that passes downward in company with the inferior maxillary division of the fifth nerve and enters the mandibular canal. It gives off branches to the lower teeth as it passes through the canal and then emerges on to the chin as the mental artery through the foramen of the same name. (*c*) Branches to the muscles in the maxillary region given off as the artery traverses the zygomatic fossa. (*d*) In the sphenomaxillary fossa small branches that enter the posterior dental canals in the posterior portion of the superior maxillary bones and supply the upper teeth. (*e*) The infra-orbital artery, which enters the orbital cavity through the sphenomaxillary fissure in company with the superior maxillary nerve. It passes forward on the floor of the orbit and enters the infra-orbital canal to emerge on the face through the infra-orbital foramen. While in the infra-orbital canal, it gives off branches that supply the upper bicuspid, the cuspid and incisor teeth. (*f*) The descending palatine artery which enters the posterior palatine canal and comes out on the hard palate through the posterior palatine foramen and supplies the hard palate. (*g*) The sphenopalatine artery which is the terminal branch. This artery enters the nasal cavity through the sphenopalatine foramen, passes forward on the nasal septum and then downward to emerge on the hard palate through one of the foramina found in the incisal fossa. It is then known as the naso-palatine artery and helps supply the hard palate, anastomosing with the descending palatine artery.

The Lymphatics of the Mouth.—The mouth is well supplied with lymphatics which form rich networks of capillaries in the mucous membrane. These capillaries drain into larger vessels which are connected with groups of lymphatic glands. Most of the lymphatic vessels from the mouth proper, *i. e.*, the cavity internal to the teeth, empty their contents into the cervical lymphatic glands. Some, however, from the lower jaw go to the submaxillary glands. Those draining the vestibule of the mouth are connected with the submaxillary and submental glands. These in turn pass their contents to the cervical lymphatic vessels and glands.

The Salivary Glands.—There are three pairs of these glandular structures, *i. e.*: (*a*) parotid; (*b*) the submaxillary; and (*c*) the sublingual.

The *parotid* (near the ear) *glands*, one on either side, are situated

below and in front of the ears and extend from the zygoma, above, to the angle of the jaw, below. Their ducts, called Steno's or Stenson's, open into the mouth at points about opposite the upper second molar teeth.

The *submaxillary glands* are situated below the floor of the mouth, in contact with the inner surface of the mandible in the region of the bicuspid and molar teeth. The ducts from these glands join with the ducts from the sublingual glands and make their entrance into the mouth on either side of the frenum of the tongue. These ducts are known as Wharton's.

The *sublingual glands* are the smallest of the salivary glands and are situated above the floor of the mouth, in the sublingual fossæ of the mandible. As has been previously stated, their ducts join with those from the submaxillary glands and make their entrance into the mouth alongside of the frenum of the tongue.

The Fauces and the Tonsils.—The opening leading from the mouth to the pharynx is called the fauces. It is bounded above by the soft palate, below by the base of the tongue, and on either side by two pairs of muscles which receive the names of *anterior pillars* and *posterior pillars of the fauces*. Between these two pillars, on either side, lie the *faucial tonsils*. These are lymph nodes which probably act as filtering plants for the lymphatic vessels draining the mouth. Whatever other function they may have still remains a mystery.

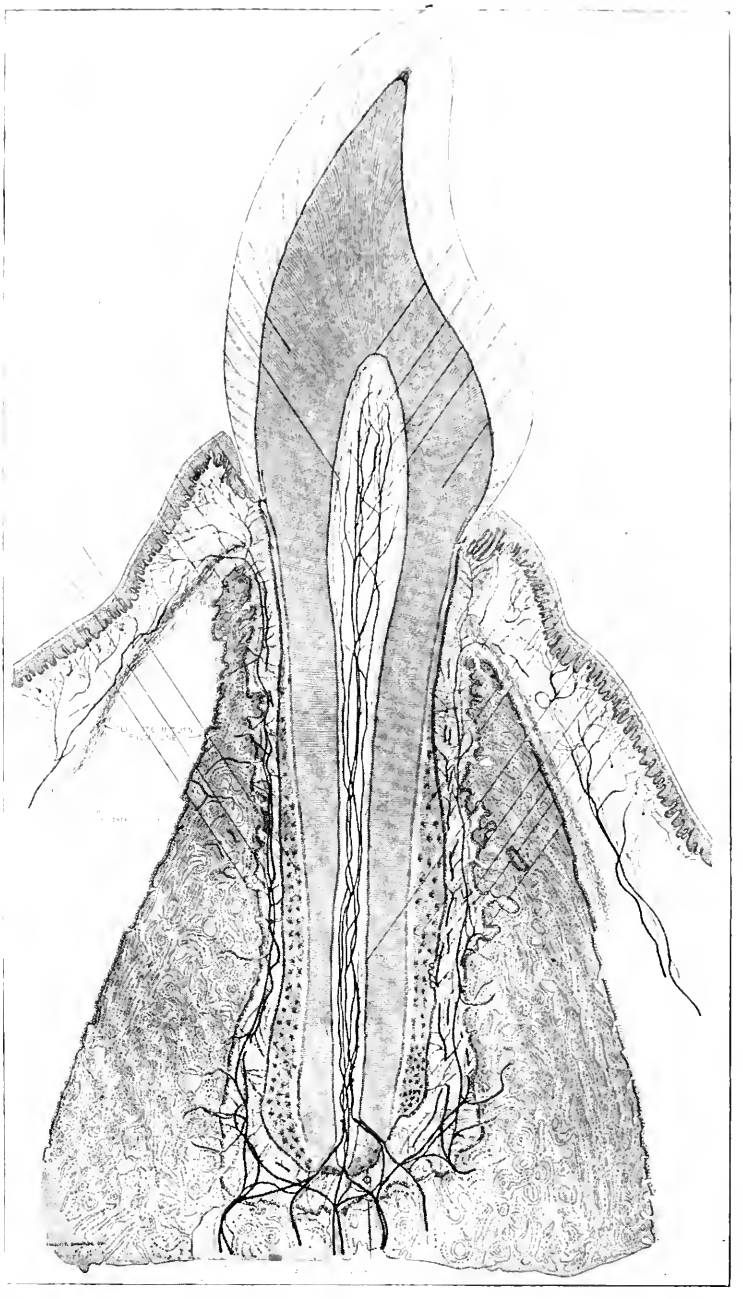
There are two other masses of lymphoid tissue in close relationship to the mouth. One has been mentioned under the description of the tongue. This is called the *lingual tonsil*. The other is known as the *pharyngeal tonsil* and is located on the posterior wall of the pharynx, just above the level of the soft palate and between the openings of the Eustachian tubes. Enlargement of the pharyngeal tonsil often occurs in children. The growth, commonly known as *adenoids*, so completely fills the upper portion of the pharynx as to shut off the passages into the nose and the child is forced to breathe through the mouth. Mouth-breathing, when continued for some time, produces very characteristic symptoms chief among which is a severe oral deformity. Blocking of the orifices of the Eustachian tubes by these growths often produces impairment of hearing.

THE TEETH.

The teeth may be defined as the calcified structures attached to the jaw-bones by the alveolar processes and having as their most important function the breaking up of food material in preparation for digestion.

The teeth must not be thought of as a part of the osseous system of the body for they are in no way related to such tissues morphologically. Their origin and structure will be presented in detail in Chapter II.

PLATE II



A Diagram of a Section Through an Incisor. (Noyes.)

Showing the bloodvessels of the pulp and peridental membrane. The bone is represented as much too dense.

The teeth make their appearance in two series or sets. The first, known as the *deciduous* (falling off), *temporary* or *milk teeth*, are twenty in number, equally divided between each jaw, and named as follows:

Central incisors.
Lateral incisors.
Cuspids.
First molars.
Second molars.

The second series or set, known as the *permanent teeth*, number thirty-two when complete. The increase in the number is accounted for by the following: There are three molars on each side in the permanent set instead of two, as seen in the deciduous. Furthermore, these are all three erupted *behind* the deciduous molars. The latter are replaced when shed by teeth known as the bicuspids. It is therefore to be noted that while the molar teeth in the deciduous set lie in contact with the cuspids, the molar teeth of the permanent set are separated from their cuspids by two teeth, the bicuspids. The permanent teeth are therefore named as follows:

Central incisors.
Lateral incisors.
Cuspids.
First bicuspids.
Second bicuspids.
First molars.
Second molars.
Third molars.

Occlusion.—The teeth are arranged in two gracefully curving arches, the lower of which is somewhat the smaller so that the upper overlaps it. The teeth of one arch do not meet those of the other in an end-to-end arrangement, but are dovetailed, as it were, between each other. This brings broad surfaces in contact instead of mere points. There are over one hundred of these surfaces that are in contact when all the teeth are present and in their proper position. These surfaces are known as *inclined planes* and it is the sliding together of these various inclined planes in a scissors-like action that properly prepares the food for digestion.

The normal arrangement of the inclined planes of the teeth when the jaws are closed is known as *occlusion or normal occlusion* (Fig. 15). In this arrangement it will be noted that every tooth, with but six exceptions, is in contact with four other teeth, *i. e.*, one on either side of it and two in the opposing arch. The teeth excluded from this rule are the lower central incisors and lower third molars which are in contact with but three teeth, and the upper third molars, which are in contact with but two teeth.

The Anatomy of the Tooth (Plate II).—A tooth is divided into two parts, the *crown* and the *root*. The crown is that portion that projects

above the gum; the root is that portion that, under normal conditions, is surrounded by gum and alveolar process. The bulk of the tooth is made up of calcified connective tissue called *dentin*. The crown portion of the dentin is covered by the hardest tissue in the body, *i. e.*, the *enamel*. This is of epithelial or lining tissue origin. The root portion of the dentin is covered with a calcified connective tissue that more closely resembles bone than any of the other tooth tissues. It is called the *cementum*. It slightly overlaps the enamel at the gum margin.

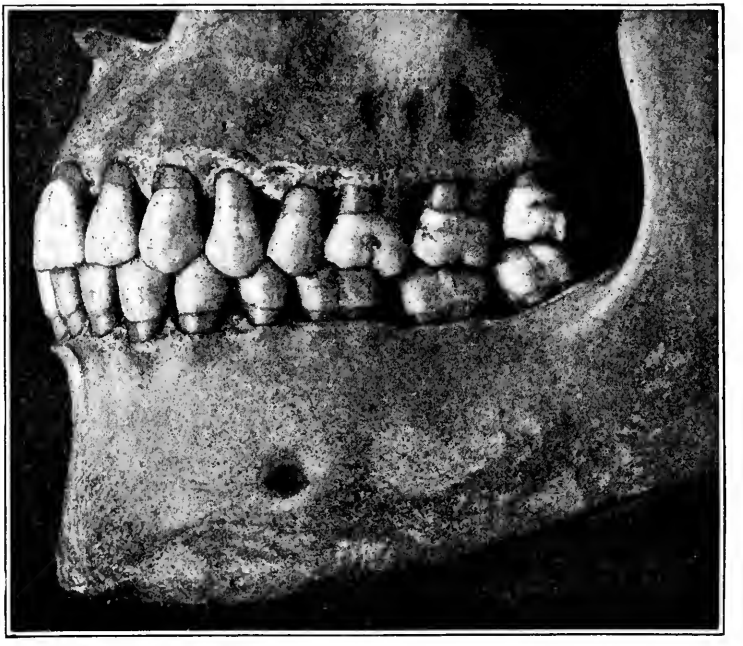


FIG. 15.—Normal occlusion. (Peeso.)

In the center of the dentin, extending the whole length of the root and more or less into the crown, is a cavity called the *pulp cavity*. This contains the remains of the organ that was active when the tooth was being formed and which during this process deposited the dentin. This organ is called the *pulp*.

The pulp cavity is divided into two parts, that in the crown, known as the *pulp chamber*, and that in the root known as the *root canal*. The root canal communicates with the exterior through a small opening at the end of the root. This opening is given the name of the *apical foramen*. Very frequently there is more than one apical foramen present. As many as seven or eight distinct openings have been noted. Through the apical foramen the bloodvessels, lymphatics and nerves pass to and from the pulp.

Surrounding the root and separating it from the bony wall of the socket is a fibrous membrane known as the *peridental membrane*. This has for its most important function the binding of the tooth to the surrounding bone. The bone that supports the teeth is known as the *alveolar process*. This is formed about the roots of the teeth as they erupt. When a tooth is removed from its process an opening is left that resembles in outline the shape of the root. This cavity or socket is called an *alveolus*.

Surmounting the alveolar process is a dense, fibrous connective tissue called the *gum*. This is covered with mucous membrane continuous with that of the rest of the mouth.

Nomenclature.

The following terms are used in describing the anatomy of the various teeth and the student will find it necessary to become familiar with these in order that the text may be clear and the parts referred to definitely fixed in mind.

The *neck*, *cervix* or *gingival margin* is that part of the tooth where the enamel and cementum meet.

The *apex* is the end of the root.

The *occlusal* end or surface is the top of the crown, *i. e.*, that portion of the tooth used in mastication.

A *cusp* is a projection or tubercle on the surface of the crown.

The *proximal* or *approximal* surface is that surface that adjoins the next tooth. The most prominent point of this surface is called the *point of contact* or *angle* of the tooth.

The *mesial* surface is that approximal surface that is nearest the median line of the arch, *i. e.*, a line drawn between the central incisors.

The *distal* surface is that approximal surface that is farthest away from such a line.

The surface of the incisors and cuspids that presents toward the lips is called the *labial surface*. The corresponding surface on the bicuspids and molars, presenting toward the cheeks, is termed the *buccal* surface.

The surface of the upper teeth presenting toward the palate is called the *palatal surface*. The corresponding surface on the lower teeth presents toward the tongue and is called the *lingual* surface. The palatal surface of the upper teeth is also often called the lingual surface.

Descriptive Anatomy of the Various Teeth.—The Incisors (Figs. 16 to 19).—The *crowns* of these teeth are wedge-shaped with the sharp edge downward. They present four surfaces and an incisal or cutting edge for study.

Labial Surface.—This is convex and on the upper incisors is irregularly quadrilateral while on the lower it is more of a triangle in outline. There are usually two grooves running vertically through this surface, known as the *developmental grooves*. All the borders of this

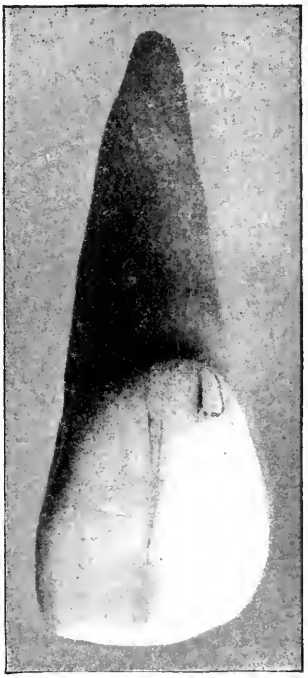


FIG. 16.—Left upper central incisor. Labial surface. (Johnson.)

FIG. 17.—Right upper lateral incisor; lingual surface. (Johnson.)

FIG. 18.—Right lower central incisor; labial surface. (Johnson.)

FIG. 19.—Right lower central incisor; lingual surface. (Johnson.)

surface are more or less convex, that at the gingivus being markedly so. This margin also ends in a distinct ridge. The *mesio-incisal angle* is quite sharp while the *disto-incisal angle* is rounded.

Lingual or Palatal Surface.—This is irregularly triangular in outline with the base downward. The surface is concave and the margins are outlined with ridges. Sometimes in the center of the cervical ridge is a rudimentary cusp at the base of which is a depression or pit.

Mesial and Distal Surfaces.—In outline these resemble arrow heads and their general surface is convex. They present two concave margins, the lingual and gingival, and one convex, the labial.

Incisal Edge.—The plane of this surface is more or less at a right angle to the crown. It is of varying thickness and in newly erupted teeth presents three tubercles. These quickly wear off as the teeth are used.

The *roots* are cone-shaped with the labiolingual diameter greater than the mesiodistal. In the lower teeth the roots are even more flattened mesiodistally than in the upper. The apex of the root often has a slight distal bend.

Each *pulp cavity* follows roughly in outline the shape of the tooth.

Individual Characteristics of the Incisors.—*Upper Central.*—This is the largest of the incisors. Its root is shorter and thicker than that of the others. *Upper lateral.* The distal surface of the crown of this tooth is very convex so that the point of contact is quite prominent and the incisal edge, oblique. Its root is the longest of the incisor roots. *Lower Central.* This is the smallest of the incisors.

The Cuspids.—The *crowns* of these teeth present for study four surfaces and an incisal edge that takes the form of a cusp.

Labial Surface (Fig. 20).—This is very convex and is marked with two developmental grooves between which is a prominent ridge. It has five borders as follows: two approximal, two incisal and one cervical. The approximal and the cervical are convex, while the incisal are usually quite straight. The disto-incisal border is the longer of the two.

Lingual Surface (Fig. 21).—This is similar in outline to the labial and also presents a vertical ridge running through the center. The cervical end of this ridge is frequently marked with a tubercle.

The mesial and distal surfaces are similar in outline to the corresponding surfaces of the incisors but are of greater dimensions labiolingually.

The Incisal Edge.—This is in the form of two planes, a mesial and a distal. The distal is the longer of the two. At their point of union they are joined by the labial and lingual ridges of the surfaces of the same name, to form the *cusp*.

The *roots* are conical, flattened mesiodistally and sometimes even concave on these sides. A distal bend at the apex is quite common. The upper cuspid has the longest root of any tooth in the mouth.

Each *pulp cavity* has the same general outline as the tooth.

Distinguishing Points between the Upper and Lower Cuspids.—The crown of the lower cuspid is more delicate in shape and slightly longer than the upper. Its root is shorter and more flattened mesially and distally.

FIG. 20.—Right upper cuspid; labial surface. (Johnson.)

FIG. 21.—Right upper cuspid; lingual surface. (Johnson.)

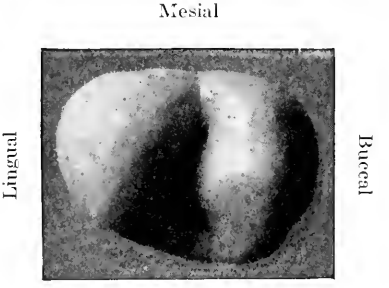


FIG. 22.—Left upper first bicuspid; occlusal surface. (Johnson.)

The Bicuspids (Figs. 22 to 26).—The *crowns* of these teeth are irregularly cuboidal in form and present five surfaces for study, *i. e.*, buccal lingual, mesial, distal and occlusal.

The *buccal surface* is convex, is bounded by five borders, and closely resembles the corresponding surface of a cuspid but is somewhat shorter than this tooth in its vertical dimension.

FIG. 23.—Left upper first bicuspid; mesial surface. (Johnson.)

FIG. 24.—Left lower first bicuspid; buccal surface. (Johnson.)

FIG. 25.—Left lower first bicuspid; distal surface. (Johnson.)

FIG. 26.—Right upper second bicuspid; mesial surface. (Johnson.)

The *lingual surface* has the same general characteristics as the buccal but is smaller in all its dimensions.

The *mesial surface* is irregularly quadrilateral and slightly convex. Its buccal and lingual borders are convex, the lingual being considerably the shorter of the two. The cervical and occlusal borders are concave. The occlusal border of the upper bicuspids is quite "V" shaped, the apex of the "V" being between the cusps.

The *distal surface* closely resembles the mesial but is much more convex.

Occlusal Surface (Fig. 22).—The outline of this surface on the upper bicuspids is somewhat egg-shaped while on the lower bicuspids it is more circular in form. It presents for study two cusps, a central groove and a mesial and distal border. The *cusps* are placed buccally and lingually, the buccal being the larger one. Each cusp has four inclines or inclined planes, as they are usually called. These are named from the surface toward which they slope, *i. e.*, mesial, distal, buccal and lingual. The *groove* runs mesiodistally and separates the cusps. The *mesial border* is nearly straight while the *distal border* is decidedly convex. Both of these borders are surmounted with ridges.

The Roots.—The upper first bicuspid has two roots. Of these the buccal is the larger. All the other bicuspids have but one root. The buccolingual dimension of the root is the greater. Its mesial and distal sides are concave. A distal curve to the apex of the root is common.

The Pulp Cavity.—The *pulp chamber* can be more readily outlined in the bicuspids than in the incisors or cuspids. Its form follows roughly that of the crown while the shape of the *pulp canal* corresponds to that of the root. The upper first bicuspids have two pulp canals, the other bicuspids usually have but one, although two may be found.

Individual Characteristics of the Bicuspids.—The *upper first* is the largest of the bicuspids. It has two roots and two root canals.

The *lower first* is the smallest of the bicuspids. Its lingual cusp is very rudimentary. Its root is broad mesiodistally on the buccal side and quite narrow on the lingual side.

The Upper Molars (Figs. 27 to 29).—The *crowns* of these teeth are irregularly cuboidal, presenting the same five surfaces for study as do the bicuspids. The crowns of the molars are smaller in diameter at the neck than at their occlusal border.

The *buccal surface* is generally convex and is divided vertically by a groove. Often in the center of this surface is a pit. When this is present the buccal groove usually terminates in it. The buccal surface has four borders. Of these the occlusal is the most striking in that it is marked with two cusps.

The *lingual surface* resembles the buccal very closely except that the mesial and distal margins converge more at the cervix as they are continued into one root instead of two as is the case with the corresponding margins of the buccal surface.

FIG. 27.—Left upper first molar; buccal surface. (Johnson.)

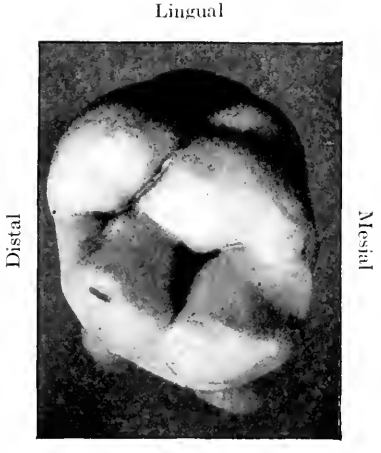


FIG. 28.—Left upper first molar; occlusal surface. (Johnson.)

FIG. 29.—Left upper second molar; lingual surface. (Johnson.)

The *mesial surface* at the occlusal third is convex while the gingival two-thirds is straight or concave.

The *distal surface* is similar to the mesial, though perhaps in general a little more convex.

The *occlusal surface* is irregularly rhomboidal, the acute angle being the mesiobuccal and the distolingual. It presents *four cusps,* two of which are buccal, called the mesiobuccal and distobuccal cusps, and two lingual, called the mesiolingual and the distolingual cusps. The mesiolingual is the largest cusp. Running obliquely across the occlusal surface there is in succession a groove, a ridge, and a second groove. The *first groove* begins in the middle of the mesial margin, and passes distally and buccally across the occlusal surface to the interval between the two cusps where it is continued over on to the buccal surface as the buccal groove. The *ridge* runs from the mesiolingual cusp to the distobuccal cusp. The *second groove* begins between the two lingual cusps as a continuation of the lingual groove and runs distally and buccally to the center of the distal margin. Just mesial and distal to the center of the oblique ridge are *fossæ.*

The Roots.—These are three in number, two being placed buccally and one lingually. The lingual is the largest root and the distobuccal the smallest. The apices of the two buccal roots tend to converge toward each other.

The Pulp Cavity.—The outline of the pulp chamber resembles the form of the crown. On the floor of this chamber are three openings leading into the *three root canals.*

Individual Characteristics of the Upper Molars.—The *first molar* is the largest of the upper molars. It is often distinguished by the fact that it has a *fifth cusp* situated at the mesio-occlusal corner of the lingual surface. This is very small and rudimentary. The roots of the first molar are usually larger and diverge from one another to a greater degree than in the other upper molars.

The *second molar* is often quite flattened mesiodistally. It never has the fifth cusp. Frequently the buccal roots show a distal inclination.

The *third molar,* with the lower third molar, is the most variable tooth in the head. If typical it should present but three cusps, the distolingual being lost. It has no oblique ridge, but presents instead a central fossa. There may be three roots or there may be but one, and the root canals vary with the number and position of the roots.

The Lower First Molar (Fig. 30).—The *crown* of this tooth is also irregularly cuboidal, and presents five surfaces for study.

The *buccal surface* differs from the buccal surface of the upper molars in that it is longer mesiodistally and presents two grooves instead of one. Its occlusal border is surmounted by three cusps instead of two.

The *lingual, mesial* and *distal surfaces* all resemble the corresponding surfaces of the upper first molar.

The *Occlusal Surface* (Fig. 31).—This differs considerably from the

corresponding surface of the upper. It is a trapezoidal in outline with the long side buccally and is marked with five cusps, five grooves and

FIG. 30.—Right lower first molar; buccal surface. (Johnson.)

a central fossa. The *cusps* are arranged three buccally, named from mesial to distal, mesiobuccal, buccal and distobuccal; and two lin-

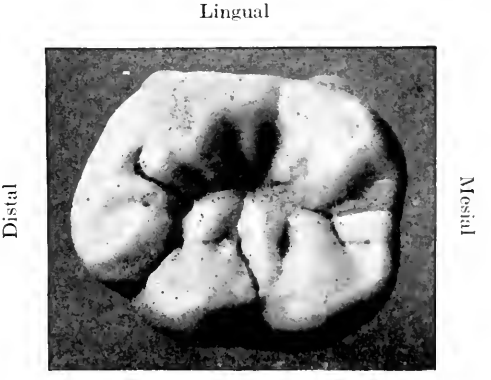


FIG. 31.—Right lower first molar; occlusal surface. (Johnson.)

gually, named mesiolingual and distolingual. The *grooves* radiate from the central fossa and are named mesial, buccal, distobuccal

(between the buccal and distobuccal cusps), distal and lingual. The mesiobuccal cusp is the largest and the distobuccal the smallest.

The Roots.—These are two in number and are placed one mesially and the other distally and are known by these names. They present a distal inclination. The mesial root is the larger.

The *Pulp Cavity.*—The *pulp chamber* resembles in outline the crown. The *pulp canals* are frequently three in number there often being two in the large mesial root.

The Lower Second Molar (Fig. 32).—This resembles the first lower molar but is a smaller tooth and has but four cusps, the distobuccal being absent. The cusp corresponding to the buccal cusp of the first molar receives the name of distobuccal in the second molar.

FIG. 32.—Right lower second molar; lingual surface. (Johnson.)

The *occlusal surface* presents a central fossa and four grooves radiating from it.

The *roots* are somewhat smaller and are situated close together. But two *root canals* is the usual order. The roots have a marked distal inclination.

The Lower Third Molar.—This is extremely variable in form but when typical should resemble the second molar in miniature.

Descriptive Anatomy of the Deciduous Teeth.—The deciduous teeth resemble the permanent teeth in their general form but are of course much smaller. Their cusps are not as well defined and the form of the

molars and cuspids is such that they are larger at the neck than at the occlusal border.

The *incisors* and *cuspids* are very much like the corresponding teeth in the permanent denture; the *lower first molars* quite closely resemble the lower second permanent molars; the *second molars*, both upper and lower, are similar in design to the upper and lower first permanent molars; the *upper first* molars, however, are different in certain respects from any of the other teeth and therefore require a more detailed description.

The Upper First Deciduous Molar.—The *occlusal surface* presents three cusps, two buccally and one lingually. The latter is so large, however, that it makes this side about as long mesiodistally as the buccal. This surface presents a central fossa with three grooves radiating from it, *i. e.*, a mesial, a buccal and a distal.

The *buccal surface* resembles that of any upper molar; the *lingual* is very convex and has no groove; the *mesial* and *distal* are convex at their cervical borders.

Approximate Age at which the Various Teeth Erupt.—Lower teeth erupt before the upper as a rule.

The Deciduous Denture.

Central incisors, 6th to 8th month.
Lateral incisors, 8th to 10th month.
First molars, 10th to 16th month.
Cuspids, 16th to 20th month.
Second molars, 20th to 30th month.

The Permanent Denture.

First molars, 5th to 7th year.
Central incisors, 6th to 8th year.
Lateral incisors, 7th to 9th year.
First bicuspids, 8th to 10th year.
Lower cuspids, 9th to 11th year.
Second bicuspids, 10th to 12th year.
Upper cuspids, 11th to 13th year.
Second molars, 12th to 14th year.
Third molars, 17th year to any time later.

CHAPTER II.

HISTOLOGY OF THE TEETH AND ASSOCIATED STRUCTURES.[1]

By ROBERT H. W. STRANG, M.D., D.D.S.

The Enamel.—This is the only calcified tissue in the body that is derived from epithelial structures. All others have their origin in connective tissue. Enamel is also the hardest of the tissues and contains no organic matter. Chemically it is made up for the most part of phosphate and carbonate of lime. As there is no organic matter to be found in its make-up it must be designated as a dead tissue. The epithelial cells that are active in its formation are destroyed when their work is finished. Owing to the fact that enamel is of epithelial origin any diseases that have among their symptoms eruptions of the skin, such as the various contagious fevers of childhood, may produce a disturbance of enamel formation if the attack comes at the age when this tissue is being laid down. This accounts for many of the cases of pitted and poorly formed enamel seen on the permanent incisor teeth.

Enamel is composed of two structural elements: (*a*) Enamel prisms or rods, and (*b*) a cementing substance.

The Enamel Rod (Fig. 33).—These are prismatic in form, having five or six sides and their average diameter is about one-half that of a red blood corpuscle. Throughout their entire length we find them alternately constricted and expanded. When placed side by side these expansions and constrictions are not dovetailed into each other, but are arranged opposite one another.

The Cementing Substance.—Between the rods and filling up the spaces made by this peculiar arrangement of the prisms, is the cementing substance. This cementing substance is also highly calcified but is more susceptible to injury than the prisms. When enamel cracks the line of cleavage runs through the cementing substance and not across the rods. When an acid is brought in contact with the enamel the cementing substance is destroyed before the rods.

The enamel is formed from within outward so the enamel on the surface of the tooth is the last to be laid down. The prisms extend from the dentin outward and are arranged in a manner that will best resist the force that is brought upon them as the teeth are used. The prisms do not always run in a straight line from the dentin to the surface but in many places, especially where the stress is great,

[1] A résumé from Dental Histology and Embryology by Dr. F. B. Noyes.

such as on the cusps of the teeth, they are intertwined with one another something like the strands of a rope. Such enamel is called *gnarled enamel*. *Straight enamel* is that in which the prisms run in practically a straight line from the dentin to the surface.

In sections of enamel two kinds of markings are distinguished on the cut surface: (*a*) striation and (*b*) stratification (Fig. 34). The *striation* is quite like that of voluntary muscle fibers and is due to the alternating expansion and contraction segments of the rods. The *stratification* is seen in longitudinal sections only. It consists of dark bands running through the enamel. These bands are also called the Bands of Retzius from the man who first discovered them. They are due to pigment being deposited in the enamel as it is formed. A portion

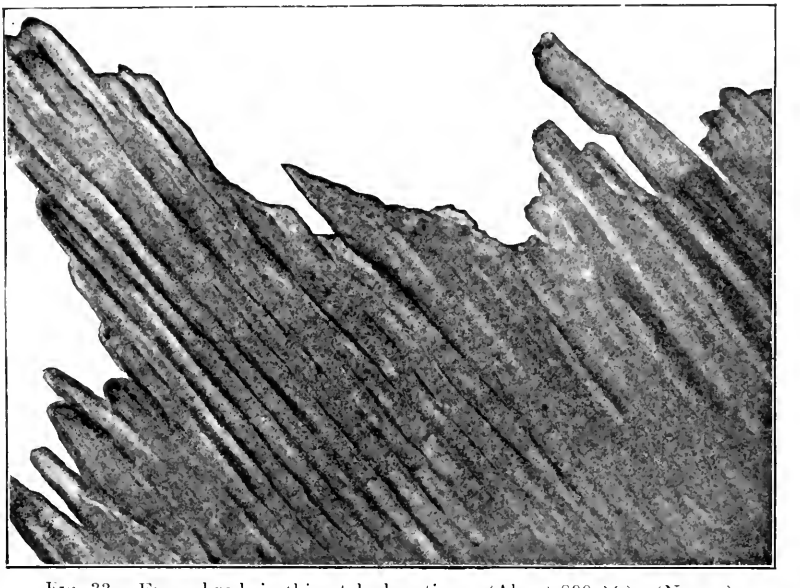


FIG. 33.—Enamel rods in thin etched section. (About 800 ×.) (Noyes.)

of the enamel having been formed, upon the surface of this is deposited pigment. Following this another layer of enamel is laid down upon which is deposited more pigment, etc. These lines of stratification are therefore an index as to just how the enamel is laid down and show that the first layer is deposited at the occlusal end of the crown and successive layers work their way rootward.

When a tooth first erupts it is covered with a thin membrane called *Nasmyth's membrane*. This is the remains of the enamel organ, active during the formation of this tissue. It soon wears off as the tooth is brought into use.

White or mottled spots are often seen in enamel. These are due to the fact that the cementing substance has not been deposited between

the rods in these areas. The air spaces left by this failure cause a difference in light refraction and make the spot appear opaque or whiter than the surrounding tissue.

Functions of the Enamel.—(*a*) It covers the exposed portion of the tooth and prevents irritation of the underlying sensative dentin.

(*b*) By its hardness it resists abrasion from the force of mastication. Enamel *differs* from any other calcified tissue in the following details:

(*a*) It is formed by epithelial cells.

(*b*) It contains no organic material either in the form of cells or intercellular substance.

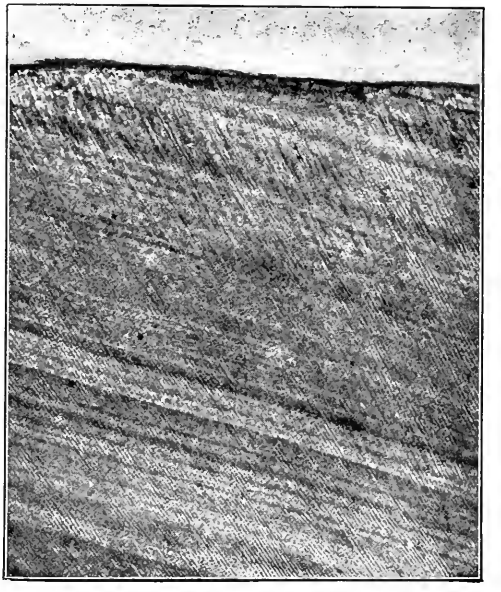


FIG. 34.—Enamel showing both striation and stratification. (About 80 ×.) (Noyes.)

(*c*) The organ that forms it disappears after its work is complete.

(*d*) It is made of prisms cemented together. All other calcified tissue has fibrous connective tissue as its structural basis.

The Dentin (Fig. 35).—Dentin is a calcified connective tissue and is used to make up the bulk of the tooth. It contains considerable *organic* matter and yields gelatin when boiled. Its *inorganic matter* is mostly carbonate and phosphate of lime.

Structurally dentin is made up of the following elements:

(*a*) Dentin matrix.

(*b*) The dentinal tubules with their walls which latter structures are known under the name of the "sheaths of Neuman."

(*c*) The dentinal fibrils.

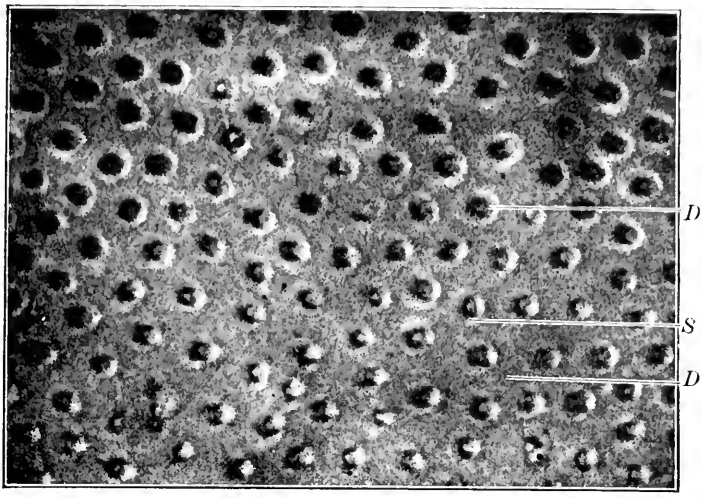


FIG. 35.—Dentin showing tubules in cross-section: *Dt*, dentinal tubules; *D*, dentin matrix; *S*, shadow of sheaths of Newman. (About 1150 ×.) (Noyes.)

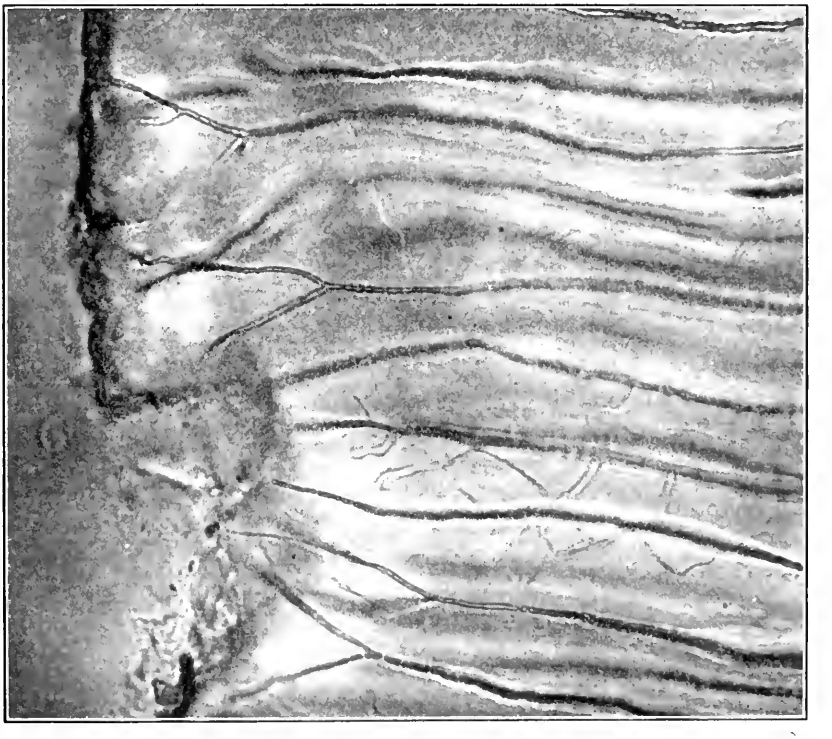


FIG. 36.—Dentin at dento-enamel junction, showing tubules cut longitudinally. (About 760 ×.) (Noyes.)

The Dentin Matrix.—This is a homogeneous material that is very elastic. As seen with the unaided eye it is yellowish. It is composed of about one-third organic material and two-thirds inorganic in the form of lime salts.

The Dentinal Tubules.—Extending throughout the matrix and radiating from the pulp cavity are minute tubes. These take a spiral course in their passage through the matrix. They also intercommunicate with one another. They end at the dento-enamel or dento-cemental junction. At the former junction they branch close to their termination in delta-like formations (Fig. 36). These deltas are in communication with one another. This intimate interconnection of many tubules explains why the dento-enamel junction is such a sensitive area under the action of instruments. At the dento-cemental junction the tubules open into spaces lying between the cementum and the dentin. These spaces, ranging as they do along the whole length of the root, form what is known as the "*granular layer of Tomes*" (Fig. 37). Although several investigators have claimed that they have found communicating channels between the granular layer of Tomes and the canaliculi of the cementum, Dr. Noyes states very definitely that he has never been able to demonstrate this fact.

The matrix immediately surrounding the tubules is of a more dense composition than that in other parts. This densely formed portion receives the name of the *sheath of Neuman*. The name is somewhat misleading for it is not a true membrane, but is undoubtedly a specialized portion of the matrix itself forming a wall, as it were, to the tubes. It has been found that the sheaths of Neuman have considerable elastin as one of their component elements.

The Dentinal Fibrils.—These are the protoplasmic processes found in the tubules and are extensions from the cells of the pulp that were active in the formation of the dentin. These cells are called *odontoblasts.*

Function of the Dentin.—(*a*) Forms the great bulk of the tooth.

(*b*) Acts as an elastic cushion to the enamel so that this tissue will not break under stress.

(*c*) Gives strength to the whole tooth.

The Cementum (Fig. 37).—This is also a calcified connective tissue. It more nearly resembles bone than does the dentin. It is arranged in consecutive layers around the tooth root and slightly overlaps the enamel at the cervical margin.

Structurally cementum is made up of the following elements:

(*a*) The lamellæ.

(*b*) The lacunæ from which radiate the canaliculi.

(*c*) Cement cells or corpuseles.

(*d*) The embedded fibers of the peridental membrane.

The Lamellæ.—This is the name given to the layers of cementum. These vary in thickness according to the position on the root, being thinnest at the gingival margin and thickest at the apex. They are

arranged concentrically about the root. There is a continuous formation of cementum going on throughout life so that the older the individual, the more layers of cementum there will be. By virtue of this property of continuous formation the cementum is the one tissue of the tooth that is capable of repairing itself after injury. Destruction of the dentin on the surface of the root may also be repaired by the cement cells filling in such areas with cementum.

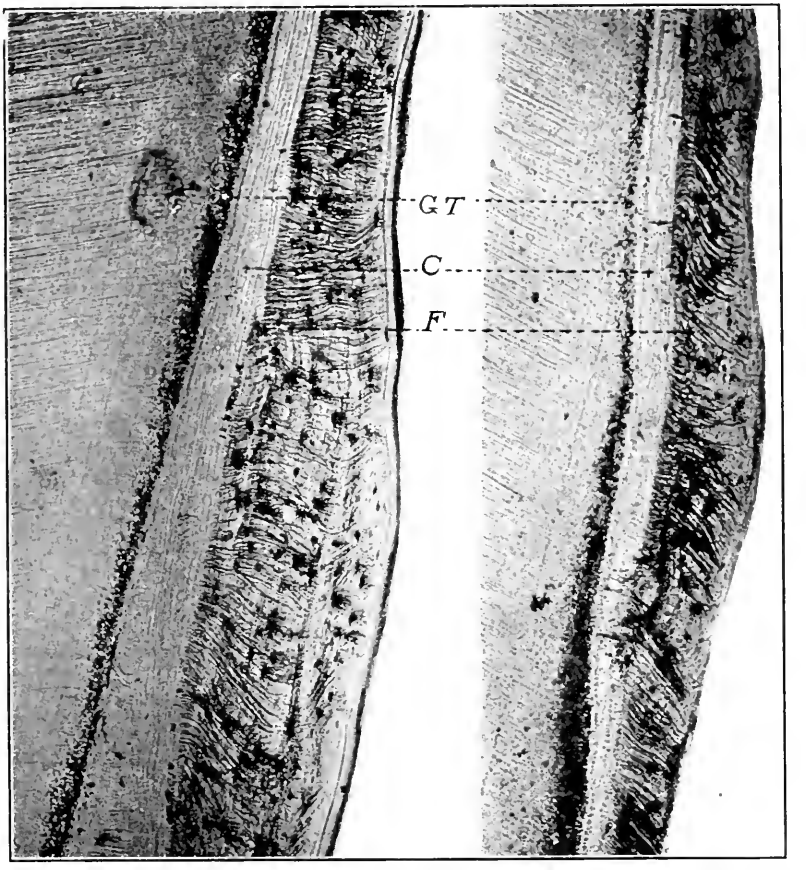


FIG. 37.—Two fields of cementum showing penetrating fibers: *GT*, granular layer of Tomes; *C*, cementum not showing fibers; *F*, penetrating fibers. (About 54 ×.) (Noyes.)

The Lacunæ.—The lacunæ are minute spaces scattered throughout the cementum, being both in the substance of the lamellæ and between the various layers. From these radiate in all directions minute canals called *canaliculi*. These canaliculi intercommunicate with those from the adjacent lacunæ. The *cement cells or corpuscles* lie in the

lacunæ. They are the cells that are active in the formation of cementum. Their protoplasmic processes extend into the canaliculi.

The Embedded Fibers of the Peridental Membrane.—The cement cells previous to the formation of cementum are located in the membrane that surrounds the root, *the peridental membrane.* The cement is built from within outward, *i. e.*, that nearest the dentin is the first to be formed. As these cells, called *cementoblasts* when active, form the various lamellæ they build themselves into the structure that they are forming. In this process many of the fibers of the peridental membrane are also built into the cementum and after a time become more or less calcified. These constitute the embedded fibers.

On the opposite side of the peridental membrane, *i. e.*, that side that is in relationship to the bone of the alveolus, we find that fibers of the membrane are similarly built into the bone. Through the agency of all these embedded fibers the tooth is firmly held in its socket.

The Function of the Cementum.—It is the tissue which through its ability to attach the tooth to the surrounding connective tissue, holds it in position. The cementum may therefore be considered as the most important of the *tooth* tissues.

The Pulp.—This is the structure occupying the cavity within the dentin. It represents the remains of the organ that was active when the dentin was formed.

Structurally the pulp is made up of the following elements:

(*a*) Odontoblasts.
(*b*) Connective-tissue cells.
(*c*) Intercellular tissue.
(*d*) Bloodvessels.
(*e*) Lymphatics.
(*f*) Nerves.

The Odontoblasts (Fig. 38).—These are the specialized connective-tissue cells that form the dentin. They lie along the periphery of the pulp in contact with the dentin walls and send long protoplasmic processes into the dentinal tubules. These processes have the property of transferring sensations of pain to the nerve fibrils within the pulp.

The Connective-tissue Cells.—These are stellate in form and resemble the connective-tissue cells in young, growing tissue. They are scattered throughout the pulp tissue.

The Intercellular Substance.—This is quite structureless and gelatinous in character. Scattered everywhere through it are the cells just described.

The Bloodvessels (Plate II).—These enter the tooth through the apical foramen and the larger vessels travel through the center of the pulp, giving off many branches. These break up into capillaries which form a rich network about the periphery of the pulp. From these the blood is collected by veins that run with the arteries and pass out through the foramen. The walls of the bloodvessels in the pulp are

extremely thin even in the arteries and larger veins. This condition renders the tissue particularly susceptible to inflammation.

The Lymphatics (Fig. 39). Recently Dr. Noyes has succeeded in demonstrating that there are lymphatic vessels in the pulp. These are connected through the apical foramen with lymphatic vessels that pass through bony spaces to the mandibular canal in the lower jaw and to the infra-orbital canal in the upper and then emerge from the mental or infra-orbital foramina and join the lymphatic vessels accompanying the facial artery and vein. They empty into the submaxillary lymph nodes. As the lymphatic capillaries pass through the apical space after emerging from the tooth root they are joined by vessels that come from the gums and peridental membrane so that there is a most complete lymphatic anastomosis between the gums, the peridental membrane and the pulp.

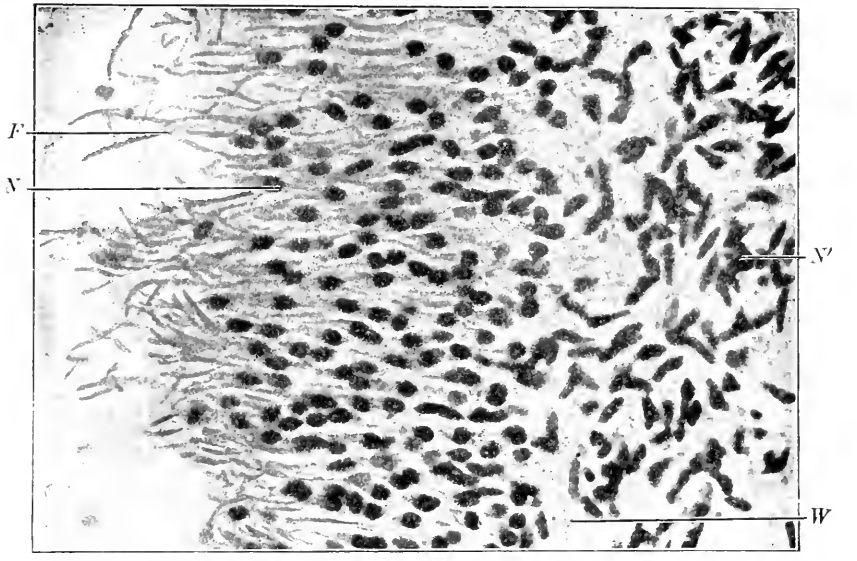


FIG. 38.—Odontoblasts. The section cuts obliquely through the odontoblasts. *F*, fibrils; *N*, nuclei of odontoblasts; *N'*, nuclei of connective-tissue cells; *W*, layer of Weil, not well shown. (About 80 ×.) (Noyes.)

The Nerves.—Several trunks enter the tooth through the apical foramen and run through the center of the pulp giving off branches. These branches pass to the periphery and form a network at the base of the odontoblasts and secondary arborizations around each odontoblast. None of the nerve fibrils enter the tubules in the dentin. Sensation in the dentin is due, therefore, to the irritation of the protoplasmic processes of the odontoblasts which transfer these irritations to the nerve fibers in physiological contact with them.

Function of the Pulp.

(*a*) The formation of dentin.

(*b*) A sensory function. It responds to heat and cold, and also gives the sensation of pain when irritated.

Secondary Dentin.—This is dentin that is sometimes formed after the normal amount of dentin has been laid down and the pulp has ceased to functionate. It is due to irritation of the pulp by some external agent and this organ responds by attempting to again perform the duties for which it was designed.

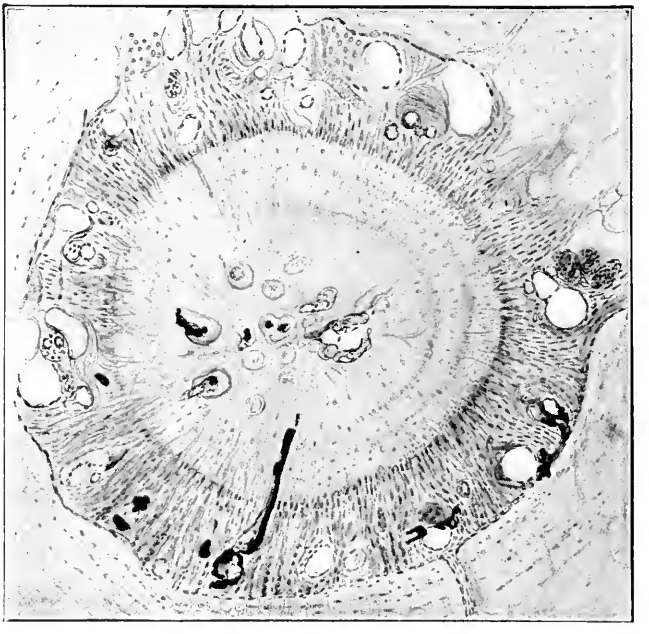


FIG. 39.—Transverse section just at the apex of the root, showing injected lymphatic vessels in the peridental membrane and in the canals passing to the pulp (oc., 2; obj., 16 mm.; reduced one-third). (Noyes.)

The Attachment of the Teeth.—As has been previously stated, the teeth are not to be considered a part of the osseous system of the body, as they bear no relation to it from a point of origin. Of what system then are they a part? It has been clearly proved that these organs are appendages of the skin that have through the processes of evolution become highly specialized into the form that we see them in the various animals and in man. The *simplest form of tooth* is seen in some of the fishes. It consists of a cone of enamel covering a calcified connective-tissue papilla containing tubules and closely simulating dentin. This in turn rests upon a second mass of calcified connective tissue like unto the cementum. Into this latter structure

the fibers of the underlying tissue are built. To such a simple form of tooth no bone is in any way related. In the attempt to find from what structures the teeth were evolved it was noted that the dermal scales on the bodies of certain fish, *i. e.*, the shark and sturgeon, were but duplicates of the simple forms of teeth just described. This fact, together with other sufficient proof, left no question but that the teeth were really dermal appendages that had migrated into the mouth.

From this simple form of tooth attachment by fibrous tissue to underlying soft parts there are numerous variations of form and methods of attachment according to the work that the individual requires of his teeth and the amount of force exerted upon them in doing this work. So it is noted that as the food upon which an animal subsists becomes harder, the attachment of the teeth becomes firmer. To combat the force of displacement, roots were evolved and bone developed about them until the perfected form of support, as seen in man, was reached.

At first thought it might seem that the strongest way in which to hold a tooth in place would be to build the bone immediately against the root so as to lock the tooth absolutely in position. If this were done, however, the slightest blow upon the crown of a tooth would either fracture it at the gingival margin or so severely shock the pulp that its life would be forfeited. Furthermore, the transmission of the force of mastication to the bones of the head under such favorable conditions would be productive of severe traumatic shock to the brain. Nature avoids all of this by placing between the root of the tooth and the bone of the alveolar process a fibrous membrane, the function of which is to literally suspend the tooth in its socket. Thus it not only retains the tooth perfectly but also acts as a cushion. This membrane is called the *peridental membrane* and may be considered as the most important of all the *dental* tissues. Why? Because it makes no difference how perfectly formed a tooth is or how carefully its contour be restored by dental operations correcting the ravages of caries, if this membrane, that bears all the stress during mastication, is not in perfect health, that tooth will be proportionately useless.

The Peridental Membrane.—Definition.—The peridental membrane may be defined as that tissue which fills the space between the surface of the root and the bony wall of its alveolus, surrounds the root occlusally, from the border of the alveolus, and supports the gum. (Noyes.)

From this definition it will be noted that this membrane not only covers that portion of the root that is within the alveolus but also that part between the top of the alveolus and the gingival line. Indeed this latter portion may be considered as the *most important part of the membrane,* because it is here that the initial lesions which eventually lead to the loss of the tooth, occur.

Structurally the peridental membrane is made up of the following elements:

White fibrous connective tissue.

Four varieties of cells:
Fibroblasts.
Cementoblasts.
Osteoblasts.
Osteoclasts.
Bloodvessels.
Lymphatics.
Nerves.
Epithelial structures.

The White Fibrous Connective Tissue.—A careful study of the distribution of this tissue is of absolute necessity if one is to realize the important role that the peridental membrane plays in maintaining the tooth in a functionating condition.

The fibrous tissues may be divided into two classes of fibers: (*a*) The principal and (*b*) the indifferent. The first group is the one concerned in the support of the tooth; the other fibers simply fill the spaces between the principal fibers and support the bloodvessels, lymphatics and nerves.

The Principal Fibers.—These are built into the cementum in the form of fairly large bundles. Upon emerging from the cementum they break up into smaller bundles, bridge across the interspace and are again gathered together to be built into the bone of the alveolar process or distributed to support the gum. This is the general arrangement. The direction, however, that these fibers take as they pass from their point of origin in the cementum to their insertion in the bone or gum is modified in various parts of the membrane and is in definite relation to the force brought to bear upon the tooth as it performs the work of mastication and upon the pressure exerted against the supported gum tissue. This adaptation is the more perfect in that this arrangement is the result of this force and the force not secondary to the building of the fibers. This is demonstrated more clearly perhaps if it is borne in mind that the cement-building cells are constantly at work shifting the attachment of fibers whenever there is a change in the direction of force exerted on the tooth. If the tooth is changed in position, the arrangement of the fibers of the membrane will be varied to accommodate any changes in the force of mastication.

For the purpose of studying the arrangement of the principal fibers, the membrane may be divided into three segments: (*a*) The gingival, that part between the border of the alveolar process and the gingival margin; (*b*) the alveolar, that part situated between the border of the process and the apex; and (*c*) the apical, that portion in relation to the apex of the root (Fig. 40).

Arrangement of the Fibers in the Gingival Portion (Plate III).—There are four sets of fibers in this area. The *first group* arises from the highest point of attachment occlusally on the root, passes from this at more or less of a right angle, then takes an occlusal curve and passes into the

PLATE III

Longitudinal Section of Peridental Membrane. (Noyes.)

Stained with hematoxylin and eosin. Showing part of the lingual gingivus and border of the alveolar process.

gum tissue to be lost among the fibers of the connective tissue that supports the epithelium of the mucous membrane.

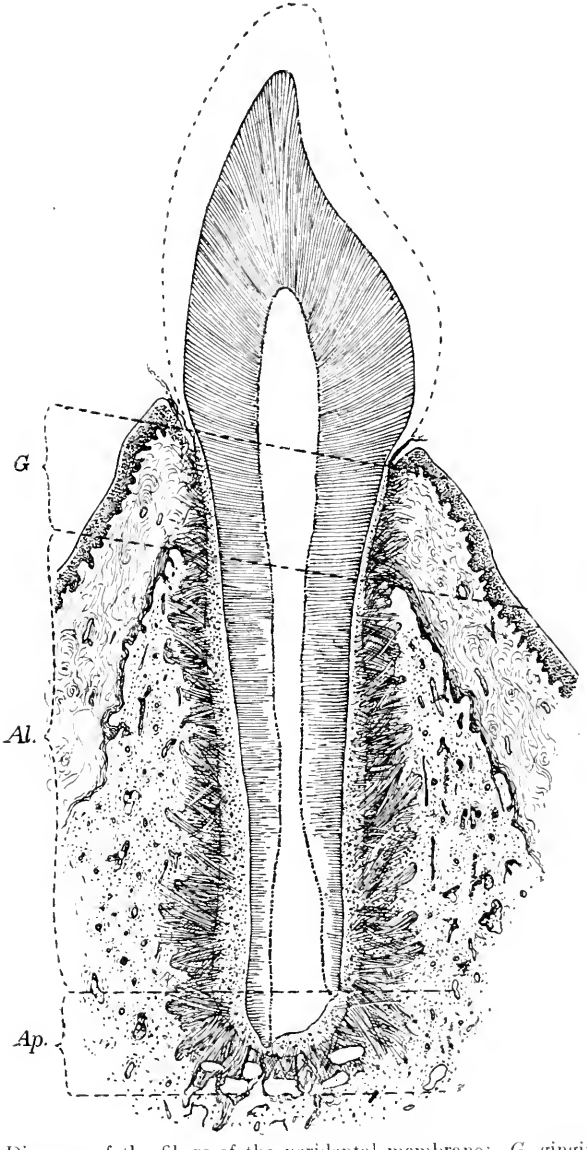


FIG. 40.—Diagram of the fibers of the peridental membrane: *G*, gingival portion; *Al.*, alveolar portion; *Ap.*, apical portion. (From a photograph of a section from incisor of sheep.) (Noyes.)

The *second group* arises from an area just below the fibers of the first group, passes out from the cementum at right angles and continues

for sufficient distance into the gum tissue to give this perfect support. On the lingual side these fibers run a longer course than on the labial because the lingual gum receives a greater shock in chewing than does the labial. The distribution of this group of fibers on the *approximal side* is of extreme importance (Fig. 41). Here they pass across the intervening approximal space to the adjoining tooth and are built into the cementum of this tooth. Each tooth receives and gives off fibers on the approximal side which are built into its cementum. These, as they

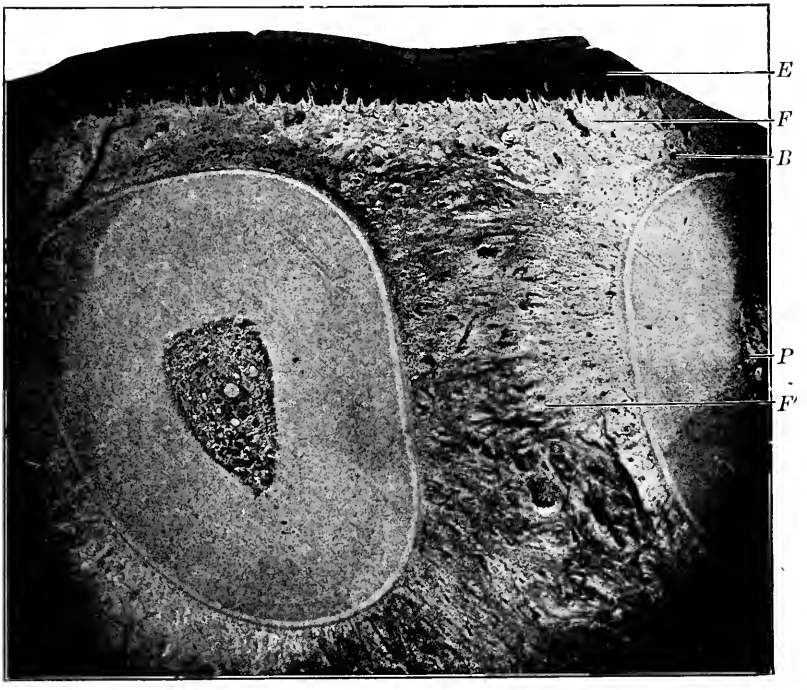


FIG. 41.—Transverse section of the peridental membrane in the gingival portion (from sheep): *E*, epithelium; *F*, fibrous tissue of gum; *B*, point where peridental membrane fibers are lost in fibrous mat of the gum; *P*, pulp; *F'*, fibers extending from tooth to tooth. (About 30 ×.) (Noyes.)

pass across the space, are closely interwoven, forming a basket-work structure that supports the overlying gum in a most perfect manner. The *third group*. A little more rootward to the second group is another set of fibers that soon after passing from their attachment in the cementum are inclined apically. These form a very strong bundle of fibers. On the labial and lingual sides they pass to the outer surface of the alveolar process and are attached to the periosteum covering the bone here. On the proximal side they either pass to the cementum of the adjoining tooth or are built into the upper surface

and sides of the bone that intervenes between the teeth. These fibers resist any force that tends to pull the tooth from its socket. They form what is known as the dental ligament.

The *fourth group* are arranged like a constrictor muscle around the gingival margin and keep the gum tissue in close contact with the neck of the tooth.

Arrangement in the Alveolar Portion (Fig. 40).—Here are found three areas of variation in direction of the fibers. *First:* The fibers coming off from the cementum at the level of the top of the alveolar process pass at right angles across the intervening space to be inserted into the bony walls of the process. This arrangement is continued down the root of the tooth nearly one-third of the distance to the apex. These fibers arise from the cementum in strong bundles and then break up into fan-like forms as they cross the space to be inserted into the bone. In transverse sections of the root at this level it is noted that the fibers that come off from the angles of the roots do not pass immediately across the space but are deflected to right and left. These are the fibers that resist any force that tends to rotate the tooth in its socket.

Second: As the lower portion of the previously considered area is approached the fibers, after leaving the cementum, begin to pass occlusally and are inserted somewhat higher up on the wall of the alveolus. This arrangement is continued until the apical end of the tooth is reached. This area is large and the fibers are strong because they have to resist the greatest force exerted in mastication, *i. e.*, the thrust force as the jaws are closed. By these fibers the tooth is actually suspended in its alveolus.

Third: At the lower portion of the apical third of the root the fibers again begin to take a more direct course from the cementum to the bone until they are passing directly across, as noted in the upper third.

The Arrangement in the Apical Portion (Fig. 40).—Here the fibers after passing from the cementum radiate in all directions before being inserted into the bone. In this way the apical space is filled with a mass of fibrous tissue.

The Cells.—*Fibroblasts.*—These are the cells that have formed the fibers and are looking after their welfare. They are scattered throughout the entire membrane.

Cementoblasts.—These are the cementum-forming cells and lie in contact with this tissue between the points of origin of the fibers. As they form the cementum some of the cells surround themselves with it and then take the name of cement cells or corpuscles. They also build into the cementum the fibers of the membrane.

Osteoblasts.—These are the bone-forming cells and have their station on the bony walls of the alveolus. They are active in forming the bone of the alveolar process that is in juxtaposition to the roots of the teeth. They too become bone cells when they have surrounded

themselves with this tissue. The attachment of the fibers of the membrane into the bone is performed by these elements.

Osteoclasts.—These are the cells that eat away the bone or cementum when there is a demand for this process. Through their action the fibers of the membrane are detached at any given area. This occurs during the absorption of the roots of the deciduous teeth and it is these cells that are responsible for this process. They are also used when nature believes that the bone in any given place is too thick and heavy for the strain brought to bear upon it. If so, these cells are brought into activity and destroy the thick bone by forming marrow spaces within it. This occurs in the formation of the alveolar process and accounts for its cancellous or spongy character.

Bloodvessels (Plate II).—The peridental membrane has a very rich supply of blood. The arteries enter the apical space from the bone beneath. They then give off branches which pass into the pulp cavity to supply the organ therein. The main branches pass occlusally in all directions through the peridental membrane. They lie nearer the wall of the alveolus than the cementum. As they pass upward they receive from and give off branches to the bone of the alveolar wall. They end by anastomosing with the bloodvessels of the gum tissue and help supply this area. From this it is noted that the blood supply of the gums and peridental membrane is intimately related so that stimulation of gum tissue by massage and brushing will in turn stimulate the peridental membrane—a fact that is of the greatest importance in the treatment of lesions of this latter structure.

Lymphatics (Fig. 42).—It has been shown that the peridental membrane is well supplied with lymphatic vessels which ramify through the membrane very much as do the bloodvessels. Small lymphatic capillaries also run from the gum margin and anastomose with the vessels in the peridental membrane. In the region of the root apex the lymph channels of the peridental membrane are joined with those from the pulp and these larger vessels pass through the bone spaces to the main trunks in the mandibular or infra-orbital canals as described under the lymphatics of the pulp.

The Nerves.—These have the same point of entrance and the same distribution as the bloodvessels that have just been described. It is important to note that these nerves give to the peridental membrane the *sense of touch.* This sense is well developed, for the lightest contact is immediately recognized.

Epithelial Elements.—As the function of these structures is still a mystery it is sufficient in this text to note that such tissues are present but that their real significance still remains unknown.

The function of the peridental membrane.

(*a*) A physical function, *i. e.*, the maintaining of the tooth in the socket.

(*b*) A vital function, manifested through the agency of its cells in the formation of cementum and bone.

(*c*) A sensory function in that it supplies the sense of touch to the tooth.

Changes in the Membrane with Age. When the tooth first erupts the space between the root and wall of the alveolus is relatively wide. Each year finds this becoming smaller and smaller because of the formation of new lamellæ of cementum on the one side and of bone on the other. The peridental membrane grows proportionately thinner

FIG. 42.—Unstained section, showing lymph capillaries of the tooth side of the gingivæ and their drainage through the ligamentum circulare to the peridental membrane. (Noyes.)

as it is thus encroached upon. However, there is always a membrane present no matter what the age of the individual may be. In other words, the bone and cementum never come in immediate contact with each other. This thinning of the membrane makes it less resistant to irritations and so predisposes inflammatory conditions. Hence diseases of the peridental membrane are more frequently found after adolescence.

The Alveolar Process.—As has been previously emphasized, the bone of this process is built secondary to the formation of the teeth or rather coincident to their eruption. It is a product of function and is arranged as to its structure in a way that will best resist the forces that are brought to bear upon it. In the *upper jaw* we find a dense, hard layer of bone about the necks of the teeth labially and buccally. In the incisor and cuspid region where much force is exerted upon the whole length of the roots the bone is quite thickened over their entire labial surfaces. This is well demonstrated in those lower animals that use these teeth for seizing and tearing their prey. Over the buccal roots of the bicuspids and molars it is very thin. Lingually, all the teeth of the upper arch are well supported.

In the *lower arch* again is found the compact bone about the necks of the teeth and their roots well supported buccally, as most of the strain is in this direction.

The *great mass of bone* of both the maxilla and the mandible is made up of the cancellated variety about the periphery of which is a layer of thick, dense bone. The wall of each alveolus joins this thickened layer at its upper border. Below this point of union the wall of the alveolus is surrounded with cancellated bone so that the alveolar process as a whole is quite elastic and springy. In connection with our reference to bony tissue it is well to mention the fact that this is living tissue, a specialization of the connective tissues, adapted for perfect support and that it is ever throughout life undergoing constant change as a result of the mechanical forces brought to bear upon it. By virtue of the ability to make such changes, nature is able to meet any requirement that is demanded, even though it be far different from the original condition for which the bone was built. So in examining a specimen of bony tissue under the microscope various forms of bone cell activity are seen going on, representing different stages of bone formation and absorption.

The Gums.—The soft tissue overlying the alveolar processes is known as the gums. It is composed of mucous membrane under which is a submucous tissue which lies on and is firmly attached to the periosteum of the bony process. The cells of the epithelial layer of the mucous membrane are cornified.

The gum tissue about the necks of the teeth is supported and held in position by fibers from the peridental membrane which pass from the cementum into the submucosa. The bloodvessels and lymphatics of the gums anastomose freely with those of the peridental membrane. Stimulation of the circulation in the gum tissues therefore also causes a free flow of blood through the peridental membrane a factor of much importance in maintaining the health of this membrane. On the other hand this free anastomosis gives excellent opportunity for infection of the peridental membrane from gum lesions or even for systemic infection.

Tooth Formation.—The first sign of the formation of teeth is seen in the embryo at about two and a half months. Along the top of each arch (upper and lower) there is seen a heaping up of the cells of the outer layer of tissue. If a cross-section is made of the arch, it will be noted that these cells are also dipping down into the underlying tissue. This formation is known as the *dental ridge*. From the lingual side of this ridge a shelf-like growth is formed called the *lamina* (Fig. 43). At intervals along the lamina, corresponding to the location of each tooth, little buds grow from it. The under surface of these buds becomes indented, taking on the appearance of an inverted cup. This cup-like structure is now known as the *enamel organ* (Fig. 44), and will soon begin to lay down enamel along its inner surface. The cells

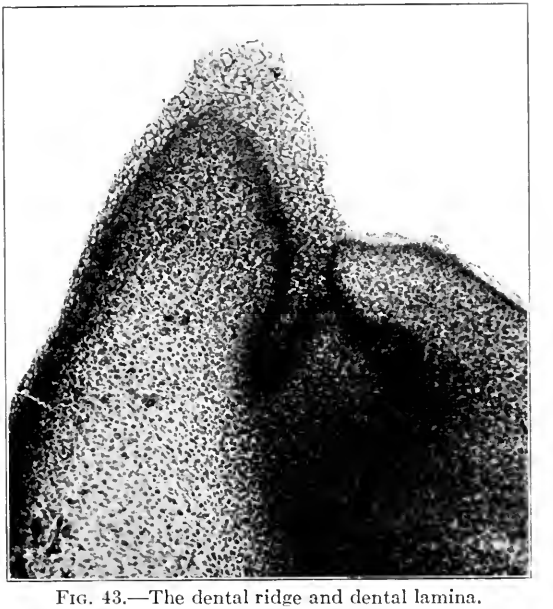


FIG. 43.—The dental ridge and dental lamina.

lining this surface are the enamel cells or ameloblasts and are active in the formation of this substance. The enamel organ is of epithelial tissue origin.

As the enamel organ is forming, the cells of the tissue into which it grows begin to take on activities. As fast as the infolding of the base of the enamel organ takes place the indentation is filled in with these active underlying tissues until a papilla is formed. This is known as the *dental papilla* (Fig. 44). This structure is of connective-tissue origin and will become active in the formation of the dentin. Growth of the papilla continues until it has assumed the shape of the crown of the tooth to be formed. To this structure formed by the enamel organ and dental papilla is given the name of *tooth germ*.

After the dental papilla has been formed, the cells at its base develop fibrous tissue which grows up and around the outer side of the enamel organ and over its top so that the tooth germ is enclosed in a fibrous sac. This combination of structures, *i. e.*, the fibrous wall, the papilla and the enamel organ constitutes the *dental follicle*. This is completed by the end of the twelfth week.

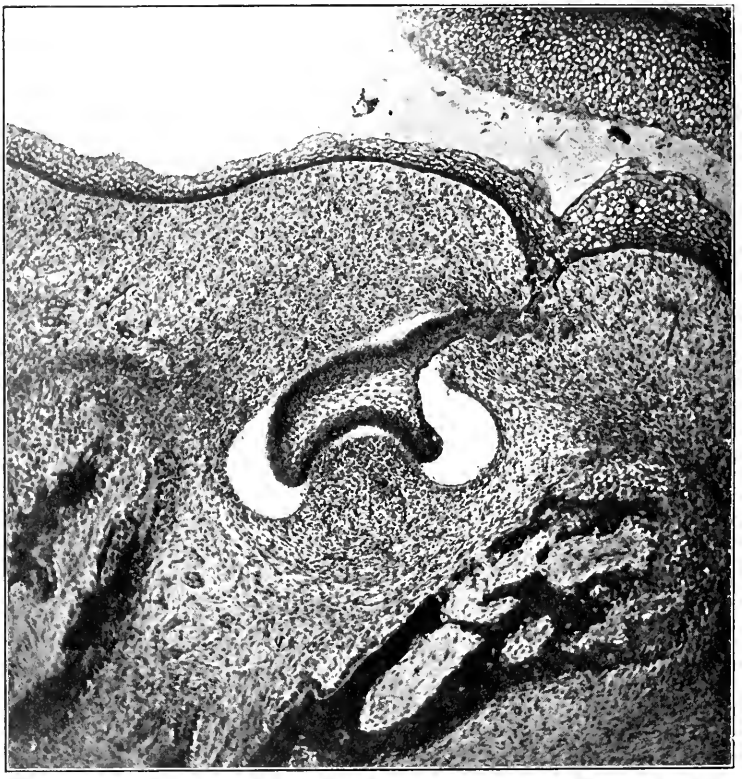


FIG. 44.—The enamel organ. The outer tunic connected to the lamina by the cord; the dental papilla growing up into the cap. The spaces are shrinkage spaces. (Noyes.)

Just before the enclosure takes place a secondary bud is given off from the enamel organ, usually near its point of origin from the lamina, which grows downward to become the enamel organ of the permanent tooth (Fig. 45).

Soon after the formation of the dental follicle the bone of the jaw below this structure sends up processes which pass to the lingual and labial side of the follicle. Later bony growth appears on the proximal sides and finally the top is covered over. This bony structure is what is known as the *dental crypt* and simply serves as a protection to the forming tooth. The dental crypt persists until the entire crown is

developed and the tooth ready to erupt when the top is absorbed and the tooth passes into the mouth.

At about the sixteenth week the dentin and the enamel begin to form, the former on the outer edge of the dental papilla and the latter on top of this dentin.

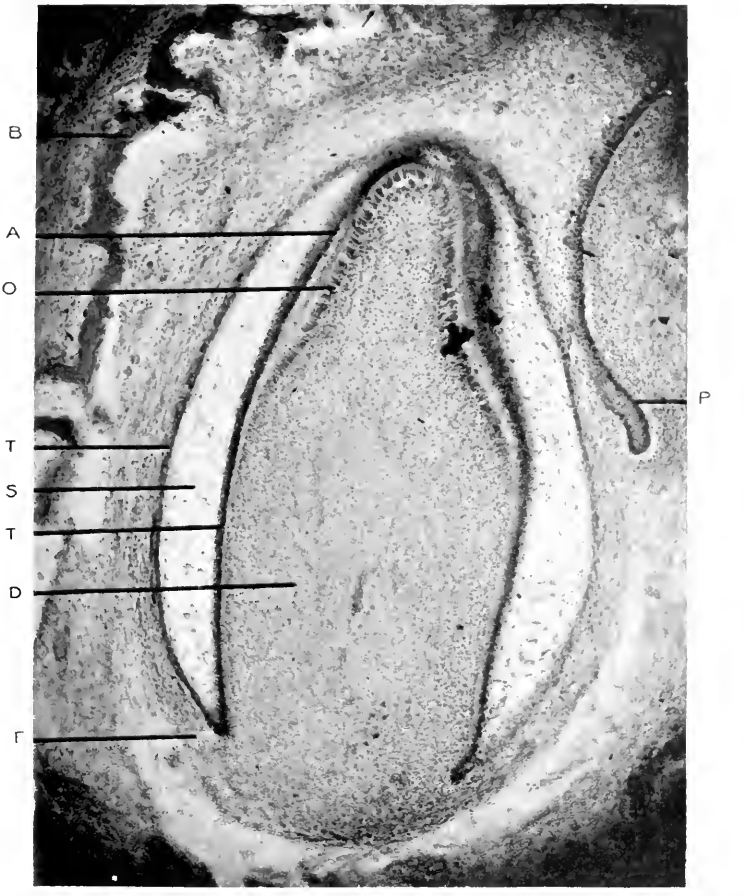


FIG. 45.—The tooth germ showing the bud for the permanent tooth at *P*. Calcification is just beginning; *F*, follicle wall; *D*, dental papilla; *T*, inner tunic; *T'*, outer tunic; *S*, stellate reticulum; *O*, odontoblasts; *A*, ameloblasts; *B*, bone. (Noyes.)

The roots of the teeth do not appear until the tooth begins to take on the process of eruption. At this time also the first of the cementum is seen. This is formed by cells in that fibrous tissue that grew up and around the enamel organ to complete the follicle. This fibrous tissue now may be considered as the peridental membrane. Coincident with the formation of cementum by the cells on the inner side

of this membrane there is a deposit of bone laid down by the osteoblasts on the other side of the membrane. This is the beginning of the alveolar process.

The first permanent molars are the only permanent teeth for which the enamel organ arises directly from the lamina. The enamel organs for the second and third permanent molars arise from the buds of the first and second permanent molars respectively.

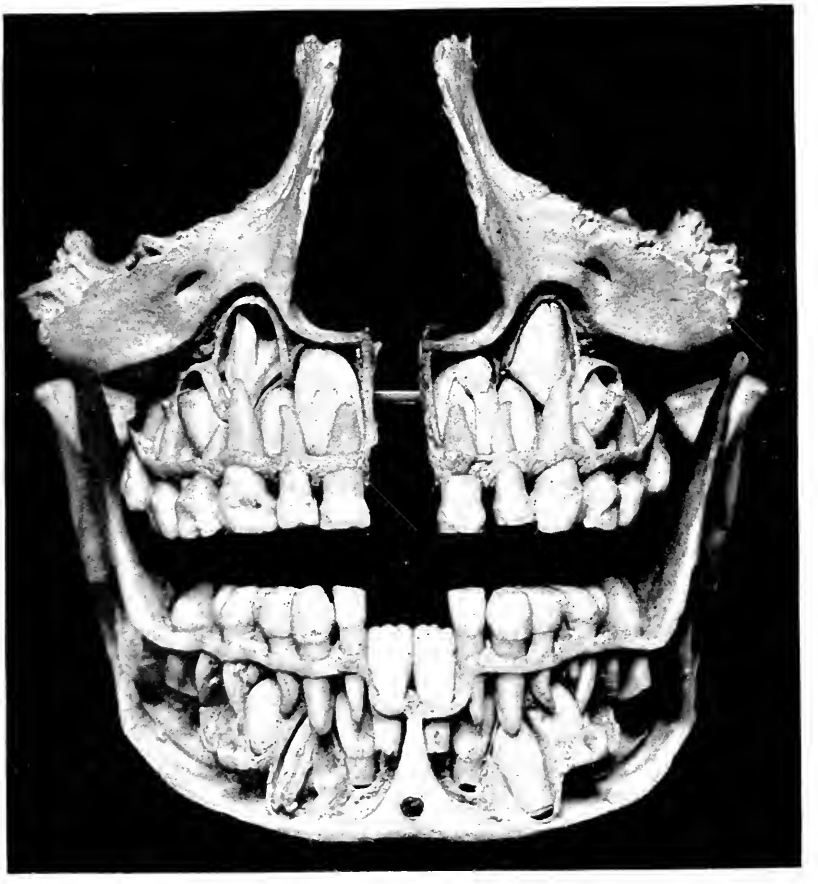


FIG. 46.—Front view of skull. Note the relation of the permanent incisors and cuspids to each other and the roots of the temporary teeth. (Noyes.)

THE DEVELOPMENT OF THE JAWS.

While it is impossible in the space alloted this subject to go into detail regarding the growth of the jaws, yet it is quite necessary that the dental hygienist should know briefly the plan upon which nature builds under normal conditions. For an exhaustive study

of this subject the student is referred to Dr. Noyes's text-book, *Dental Histology and Embryology.*

In a comparison of the skull of an infant at birth with that of an adult it is noted that as growth proceeds there is practically twice as much development below the nasal spine of the frontal bone as above it. This great *downward* growth takes place mostly in the region of the mouth and is due primarily to the formation and subsequent eruption of the teeth, and secondarily to a continued growth of bone thrown out to act as a supporting structure for these organs (Fig. 46). This downward growth begins with the eruption of the deciduous denture and continues until all the permanent teeth anterior to the first molars are in position. After the completion of the deciduous denture two new directions of growth manifest themselves, a *lateral* or expanding growth to allow for the difference in size between the teeth of the deciduous and permanent dentures, and a *forward* one to make room for the developing permanent molars. Hence we note that the growth and development of the jaws takes place in three directions, *i. e.,* a vertical growth, which is downward in the upper jaw and upward in the lower and is coincident with tooth eruption; a lateral growth; a forward growth. This development continues until all the teeth are in position and occlusion is established.

CHAPTER III.

THE TEETH AS A MASTICATING MACHINE.

By CHARLES R. TURNER, M.D., D.D.S.

An analysis of the reasons for preserving the teeth gives first importance to their preservation that they may perform their functions as a part of the human organism, and play their part in that sum total of activities which go to make up the physical life of the human animal. As so much attention is now being given to the matter of tooth conservation it is proper to be informed as to the important part taken by the teeth in one of the most essential of the distinctive animal functions, indeed, one which is necessary to the preservation of life itself. Furthermore, it is one of the dictums of physiology that any part of the body which ceases to perform its functions atrophies, or the character of its tissues degenerates, and in course of time is incapable of performing its function; and so the duties of the teeth have a twofold interest for us.

In order then to present the case for the preservation of the teeth, as it were, something must be said about their functions in the human body, and in that connection as a machine, or as a part of a machine, concerned in the preparation of the food for subsequent stages in the digestive process.

To appreciate fully the part taken by the teeth in the activities of the human organism, it might be interesting, and it will certainly give a good background for the study of the human dental mechanism, to take some account of the way the teeth have developed to perform their present functions.

The basal functions of animal as distinguished from plant life, and as fundamental to existence itself, are:

1. Alimentation.
2. Respiration and circulation.
3. Locomotion.
4. Reproduction.

Evolution of Tooth Forms.—In the simplest form of animal life, as for example in a unicellular body, *the ameba*, we have the process of alimentation, or the securing of nutrition, an extremely simple one. The animal is afloat in the water and extracts its nutriment therefrom, the nutritive elements are absorbed through the cell wall and nutrition is effected through a simple process of osmosis.

No one fact so impresses the student of zoölogy as the relation-

ship between the form and structure of the various parts of an animal organism and the functions they are called upon to perform. It is very interesting to note the adaptive modification of the structures to changes in these bodily functions, and to observe how they have been modified during the various stages in the development from the lowest organisms up to the highest forms.

As the scale of animal life is ascended and a multiplication of functions occurs, differentiations of tissue appearing here and there are found, which occur as a result of a certain function falling upon that tissue. Certain cells are given over to the function of reproduction; certain other cells or collections of cells are specialized for locomotion, etc.

In some of the lower forms of animals, before the vertebrates, there is a simple tube like a channel devoted to alimentation; the food goes in one end and the excreta are ejected at the other. There is no special collection of cells at the beginning of this tube to prepare the food. In the *cœlenterata*, for example, the alimentary canal is not separate from the general body cavity, but in the *annuloida* and *annulosa* it is a distinct tube.

A little higher in the scale, as in some of the insects, the crabs and the crustaceans, there are, at the beginning of this alimentary tract, cells which are concerned to some extent with the preparation of the food for its passage through the canal. There is no real masticating apparatus, however, even in many of the lowest of the vertebrate animals, but the first thing that at all appears like it occurs in some of the lower fishes, in the *hag-fishes* and in the *lamprey eels*. The latter have a suctorial mouth which they attach to some object, either the side of a larger fish or a stone covered with moss, and obtain their nutrition from it by a process of suction. Inside of this mouth are layers of cells which are rather horn-like in character. They are for the purpose of imbedding themselves in the substance to which the mouth is applied and of affording a firm hold so that the animal may draw its sustenance. This is perhaps the very simplest type of differentiation of tissue for this purpose.

In the vertebrate animals the cells constituting the tissues at the entrance of the alimentary canal are specialized with a view to assist ing in the process of either securing or preparing the animal's food. The apparatus is simple in the less highly developed orders and becomes a more complicated instrument as the scale is ascended. The food convenient to the animal or required by it, and the food-reducing mechanism are in constant correspondence. Out of this necessity has developed teeth. The teeth have developed in accord with and to meet the needs of the food which the animal utilizes. They are corneal or horn-like in some of the lower orders and as we go upward they become calcified. They are simple cones or they are modified under certain conditions to forms which serve better their functions.

Fishes are the lowest vertebrate type that have calcified teeth; they are simply calcified cones arranged around the border of the jaws and serve to hold the food. Some of the teeth are recurved and serve like the barb of a fish-hook to prevent the escape of the prey (Fig. 47).

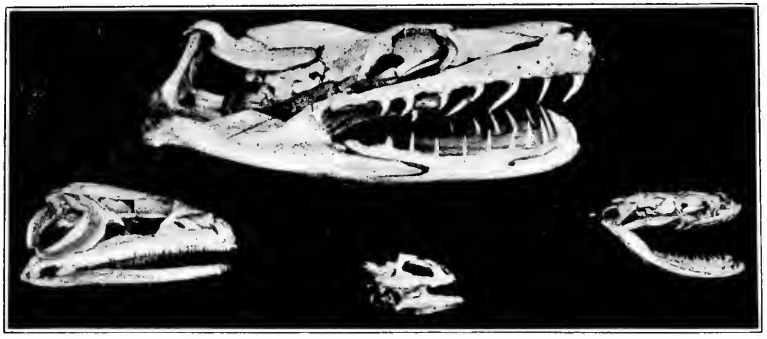


FIG. 47.—Teeth of the python, bull-frog, horned toad and water snake.

Of the *amphibians* some have no teeth, as the toad, while others, such as the *frog,* have teeth not unlike those of fish, at least always in the upper jaw for the *bullfrog* has no lower teeth.

Of the *reptiles* many have teeth. The lizards eat butterflies, worms, insect larvæ, etc., while *snakes* live on amphibians and their larvæ and fish, and the *viperine snakes* on small mammals. *Crocodiles* and *turtles* eat fish, small amphibians and insects. The snakes do not chew their prey but swallow it whole. The lower jaw is jointed in the center and articulates with the skull through the quadrate bone, thus allowing the mouth to open very wide, but the teeth serve only for seizing and holding the prey. In the venomous snakes in the upper jaw are found the "poison fangs" which have a channel leading to the poison sac. The *chelonidæ* or *turtles* have a horn-like covering for the border of the jaw.

The *birds,* of course, have no teeth, the beak being a horny sheathing of the ends of the jaw bones. In some the edge is serrated. In no other class is found a greater variation in the food-preparing apparatus, or greater adaptation to the food supply. The beak serves largely to obtain the food. In the grain-eating birds the gizzard performs mastication. Ducks have soft-edged beaks for sifting the food out of the mud. The skulls of the *hawk, heron, English sparrow, crow* and *toucan* shown give an idea of this variation. The crow subsists largely on grain, and very often takes grain such as corn out of the husk. It has rather a strong beak suited for this purpose (Fig. 48).

The skull of the *blue heron* is also shown. These are aquatic birds and their food comes from the bottom of the water, or in fact, down in the mud where they go after little frogs and little fish, and various

other inhabitants of the water. Also is shown *passer domesticus* or *English sparrow*, which subsists on very much the same type of food as the crow, only it is a little more omnivorous, and the beak is very much the same. We also have the skull of a South American bird, the *toucan*, which is a fruit-eating bird. The serrations on the beak,

FIG. 48.—Beaks of birds, showing functional modifications.

which are useful in cutting through the skin of fruit and in sifting out the stones, will be noted as a rather interesting adaptation to the needs of this bird. Lastly, we see the skull of the *hawk*, one of the carnivorous birds. The beak of the hawk is very strong, and is used

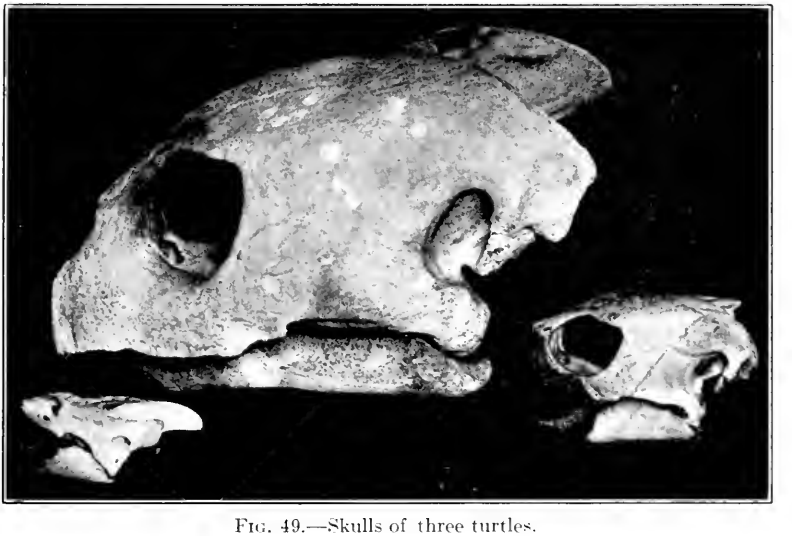


FIG. 49.—Skulls of three turtles.

for the purpose of killing the prey; smaller birds and mammals, in the case of large hawks, and insects and food of that sort in case of smaller hawks.

There is very much the same type of masticating apparatus, if it may be so called, in the *turtle*. Fig. 49 shows the skull of a large

green turtle, the *hawk-bill turtle* and the *snapping turtle*, the beaks of the last two mentioned covered with a very hard, dense membrane, which is very horn-like in quality, and is very much like the beak of birds, the purpose of it being purely to crush the food, and to cut off a definitely sized amount of food in order that it may be swallowed. Of course it is not possible for this animal to chew its food.

The first type of tooth that is of very great interest other than merely as a fang, or something of that sort, is the molar of the *ungulates* which are herbivorous and granivorous animals (Fig. 50). Herbivorous animals live on grain and on vegetable fiber, both of which require considerable trituration in order to be successfully acted upon by the digestive juices, solvents and ferments farther down in the digestive tract. For example, corn and other grains will pass down the alimentary tract of any of these animals, entirely untouched unless the outer membrane is broken, therefore in order to be successfully digested they have to be well triturated.

FIG. 50.—Skull of a sheep.

The series of molar teeth of the horse is a real grinding machine. The surface is raised into elevations alternating with depressions. The elevations are the enamel, the depressions between, the cementum. The cementum is very much softer, and as the tooth wears down the enamel which is harder and more resistant than the cementum wears much less rapidly, so that the surface is continually kept rough for grinding purposes.

This animal has a great latitude in the side-to-side movement of the jaw; or, to speak more technically, the lateral excursion of the mandible of herbivorous animals is very marked. The jaw does not move much backward and forward; in fact, it hardly moves in these directions at all, but it moves from side to side. The result is that

these serrations run from front to back. This is exactly the reverse of the form of the molars found in the rodents, in which a backward-and-forward movement of the mandible is responsible for the grinding, necessitating a different arrangement of the occlusal surface of the teeth.

John Ryder, many years ago, pointed out the fact that from an examination of the surfaces of the molar teeth of any animal, extinct or living, he could without reference to the skull indicate the way in which the mandible was accustomed to move.

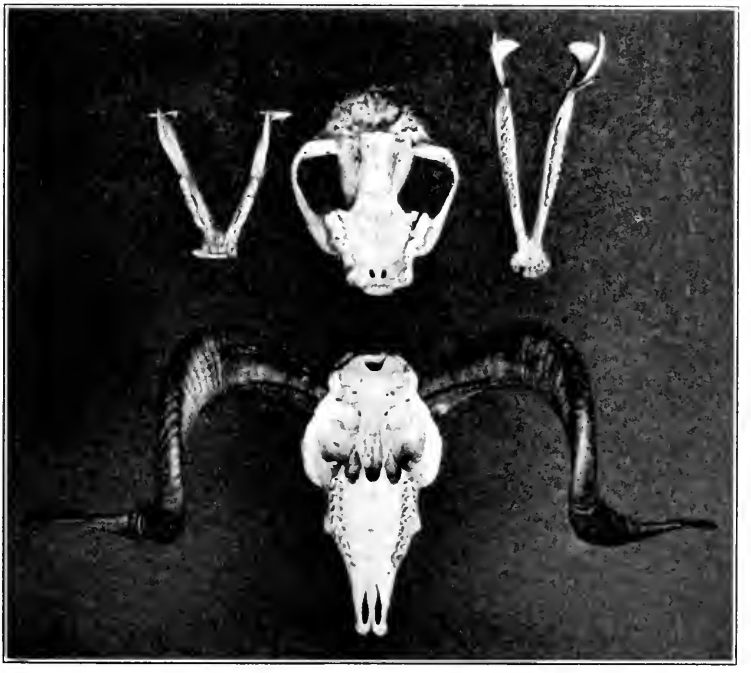


FIG. 51.—Carnivorous and herbivorous skulls.

The front of the mouth of the horse is provided with incisor teeth which bite and pinch off the grass and other foods which the animal secures. The canine is quite rudimentary, and usually absent in the mare.

Cows have incisors only in the lower jaw, and the biting is done between the upper lip and the lower teeth.

Now passing over one or two important orders as not being especially interesting, next comes a very large family in the animal kingdom, the *carnivorous* animals, which differ from the class just described in the character of their teeth and also in the manner of the movement of the mandible. In studying these dentures three fundamental elements and their relationship must be constantly borne

in mind; the food supply, the teeth and the manner in which the mandible is capable of moving.

For a comparison of dentures the skulls of a large western cat and of an ordinary buck sheep are pictured together (Fig. 51). A vast difference in the grinding teeth, as shown in their respective mandibles, is noted. In one the teeth are narrow, in the other the teeth are wide. Viewed from the side it is seen that the carnivorous molars have sharp edges and are rather more like knives than the grinders of the herbivorous series. In one there are very pronounced canines.

There is a very marked difference in the temporomandibular articulation of these two animals. In the case of the herbivorous animals there are broad, flat glenoid fossæ to render possible the large range of lateral excursion of the mandible. On the other hand, the carnivorous animals have no lateral excursion. The condyles fit into

FIG. 52.—Skull of a tiger.

the fossæ so tightly as to make almost a hinge joint; and in some instances the distal part of the eminentia articularis so far overhangs its glenoid fossa that it cannot be seen. It is only with great difficulty that the condyles can be gotten out of these fossæ; indeed in some instances they cannot be gotten out without breaking the skull.

In the skull of an Indian tiger, it may be noticed that the molar teeth are of the type described (Fig. 52). They are very sharp and there are tubercles on each side just before the cingulum is reached, and in the closure of the mouth the teeth pass by each other very much like the blades of a pair of shears. Besides the articulation of the mandible which serves to keep it in line, the upper canines fit into the spaces back of the lower canines and, locking the occlusion like guide-pins, prevent lateral movement.

The carnivora have greater crushing power in their jaws in comparison to their size than any other animals. This is partly due to

the tremendous temporal muscles which are attached to the broad temporal ridges.

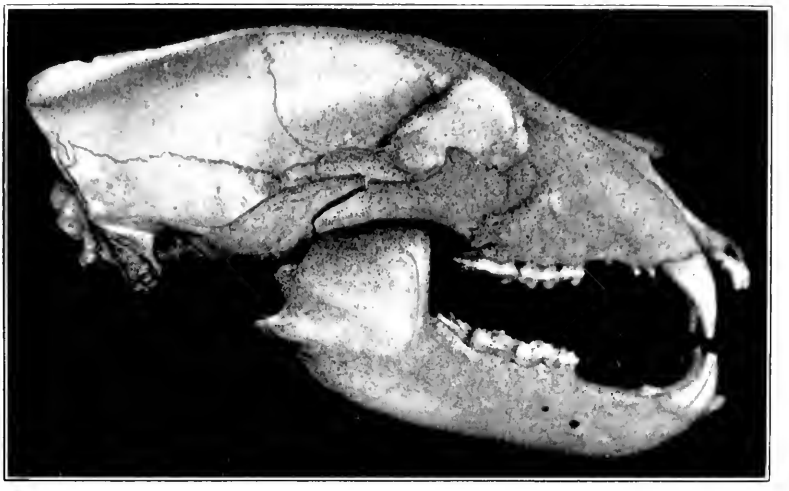


FIG. 53.—Skull of a black bear.

In the skull of a *black bear* is observed almost the same type of dentition as that of the cats, only the canine teeth are a little less powerful, and the carnassial teeth at the rear are not so strongly marked (Fig. 53).

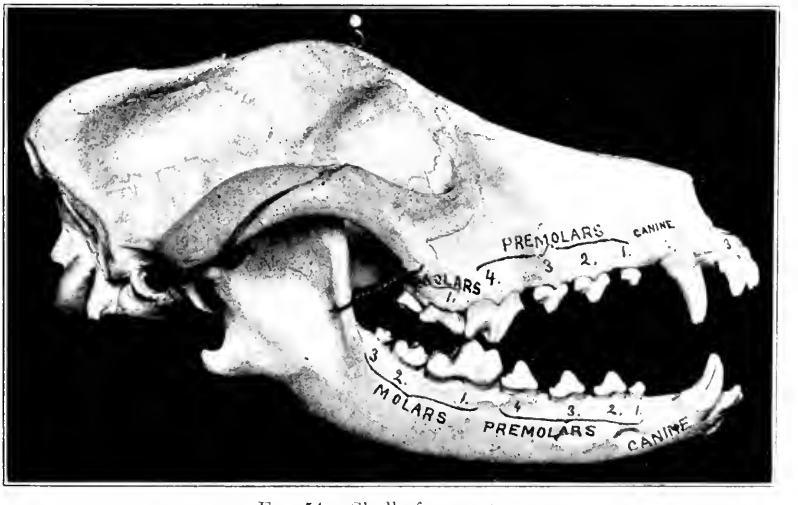


FIG. 54.—Skull of a coyote.

A typical carnivorous dentition is found in the *canidæ* or *dog* family and in a skull of the *canis latrans* illustrated are shown the several

types of teeth definitely marked; the incisors, three on each side, the canines, the premolars and the molars (Fig. 54). In the upper jaw there are four premolars and two molars, whereas in the lower jaw there are three molars and four premolars. The fourth upper premolar and the first lower molar are known as the carnassial teeth and they are the chief cutting teeth of these animals.

In the wolf and the American fox the dentition is precisely the same. In some of the smaller carnivorous animals, the badger, the otter and the raccoon, the dentition is very much the same.

The next family is the *rodents*, who have a highly developed type of incisor. Thus far attention has been given chiefly to the molar teeth. In the rodents the incisor teeth are of the greater importance. In the skull of the beaver the upper incisor tooth has a chisel-like beveled edge (Fig. 55). It has enamel only upon its labial surface,

FIG. 55.—Skulls of rodents.

which is supported by the dentin. There is no enamel on the back of the tooth. As the dentin wears away the enamel is left standing and chips away and thus always preserves a sharp edge. It is really a self-sharpening tool. It has a persistent pulp and grows out as it is worn off.

The rodents have practically no lateral motion to the mandible, but great backward-and-forward movement. Their molars are ridged, but the ridges run transversely, so that in the backward-and-forward movement of the mandible they can do the same kind of grinding as the herbivorous animals do in the lateral movement (Fig. 56).

Approaching nearer to man in the scale of animal life, as for example in the apes, dentures are found which are approximately like the human one. Thus in the *new world monkeys* (Fig. 57) almost exactly the same type of denture is observed as that of man, except that

there are three premolars instead of two. There are two incisors, a canine, three premolars and three molars on each side.

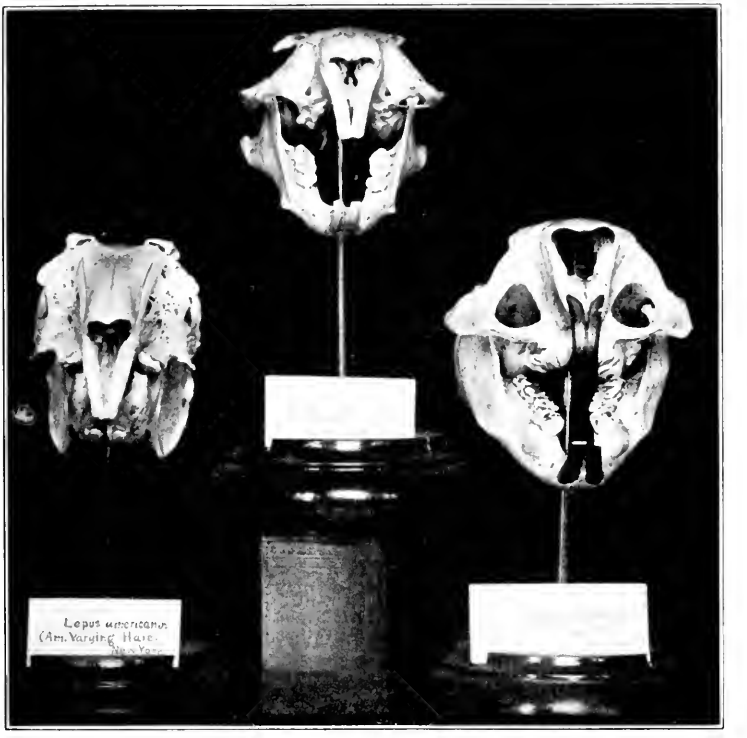


FIG. 56.—Skulls of rodents, showing transverse ridges in molar teeth.

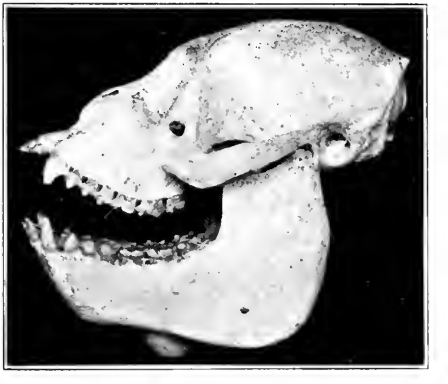


FIG. 57.—Skull of a new world monkey.

The old world monkey is the first animal representing exactly the dental formula of man (Fig. 58). The three molars, the two pre-

molars, the canines and the incisors are the same. There is, however, a space between the upper lateral incisor and the canine which is to

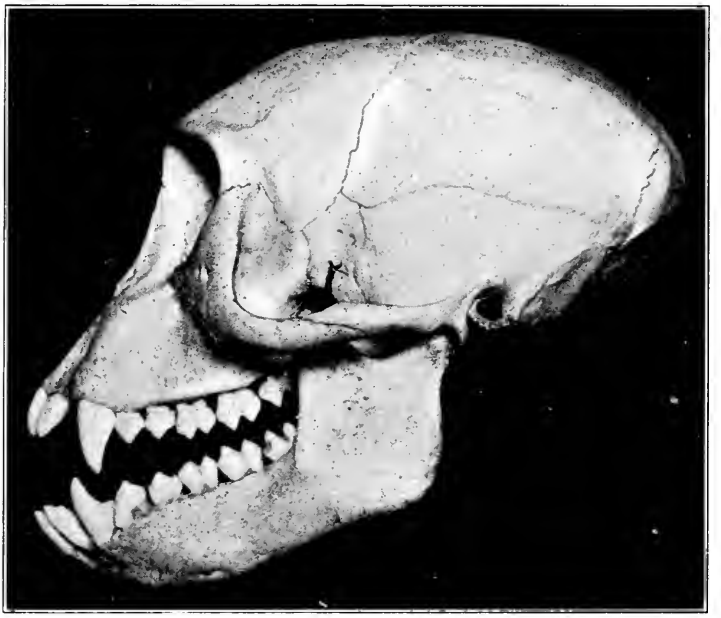


FIG. 58.—Skull of an old world monkey.

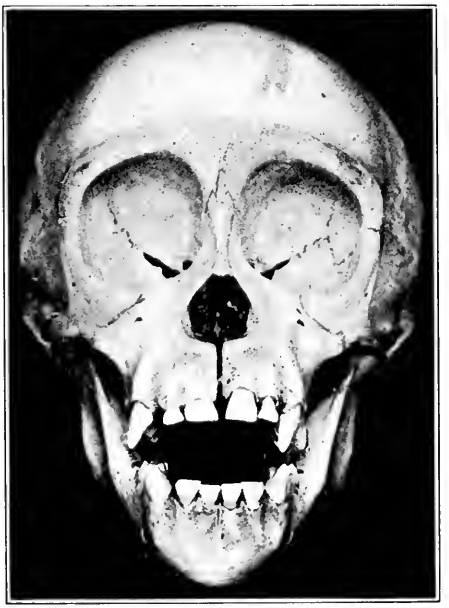


FIG. 59.—Skull of a chimpanzee, showing deciduous denture.

admit the lower canine. These animals are largely frugivorous, and their teeth are suitable for this diet.

The *baboon* has very long teeth and exactly the same dentition as has been seen before, that is, it has the same formula. The molar teeth are very much the same in general form as the human molars. The chimpanzee has a deciduous denture which is even more like that of man (Fig. 59). The gorilla has a very powerful mandible and the canines are very strongly developed.

FIG. 60.—Architectural construction of skeletal portion of masticating apparatus: the fixed base and movable arm. Columns, arches and buttresses of the fixed base; frontonasal column, *A B*, zygomatic column, *C M D*, pterygoid column (only partly visible), supra-orbital arch, *B F D;* infra-orbital arch, *B I D;* upper nasal half-arch, *B G;* palatal arch (not shown); lower nasal arch, *A H;* large molar arch, *A C;* molar buttresses (descending from *M*); pterygoid arches (not shown). Columns and arches of the movable arm; mental column, *N K;* coronoid column. *P Q O;* and condyloid column, *J L;* external oblique column, *Q N*. (From a photograph of specimen No. 4237, Wistar Institute of Anatomy.) (Turner.)

It is not such a very long step from the dentures of the anthropoid apes to one of the lower types of human denture (Fig. 60). The skull shown is not of the lowest aboriginal type, but the highly developed jaws will be noted while the skull case which contains the brain is not highly developed.

Secondary Functions of the Teeth.—It might be interesting to dwell for a moment upon certain secondary functions developed in connection with the teeth. Since secondary functions are performed by the teeth of man, those we find in the animals may be briefly viewed.

They are used as weapons of offence, as in the poison fangs of the snake, which is a very well-known example. The hypodermic needle

really had its origin in the poison fang of the viperine snakes, a tooth with a tube extending through its center and leading to the poison sac. Upon the contraction of the digastric muscle and opening of the mouth the fang is erected, and when it is driven into the prey the sac at its base is compressed and the poison injected.

The *sword fish* has a very dangerous projection which it uses to open the abdomen of fish from beneath and thus kill them. The use of teeth as weapons in warfare is well known, as in the *rhinoceros* and even our domestic animal, the *horse*. The teeth are also used for purposes of transportation and locomotion. The *elephant* uses his tusks, which are very highly developed upper incisors, to uproot trees and dig up tuberous roots. He is trained in India to use them for the purpose of transporting lumber, etc. The *walrus* uses his upper canine teeth to pull himself up on the ice, and also for digging in the mud and uncovering small fish, shell fish, etc., which he consumes. One of the most interesting of the secondary uses of the teeth is found in one of the *lemurs*. The *flying lemur* (galeopithecus volans) has curious incisor teeth, the lingual side of which is very much like the teeth of a comb and this the animal uses to comb its fur.

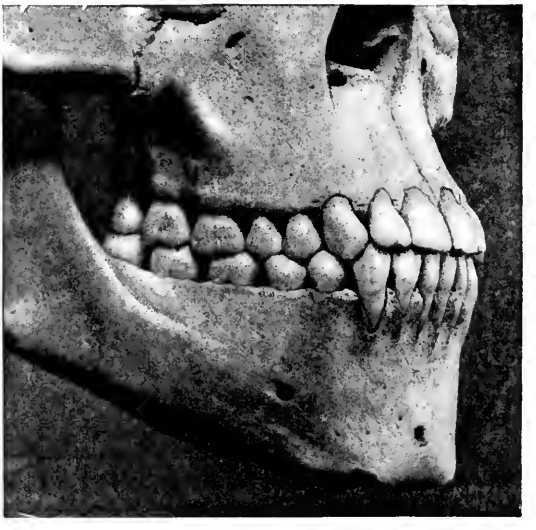


FIG. 61.—Upper and lower teeth in occlusion. (From photograph of specimen in the Wistar Institute of Anatomy.)

The Human Dental Mechanism.—The human dental mechanism primarily has to do with the preparation of the food for subsequent stages in its digestion, and it is a very interesting apparatus viewed as a machine, created for this purpose. To better understand it, for purposes of study, it may be resolved into its various elements. In the first place it consists of a fixed base and a movable arm (Fig. 61). The fixed base is the upper jaw, and the movable arm is the

lower jaw. It has been likened to a hammer and anvil turned upside down; but the metaphor of the fixed base and movable arm is a little more expressive. These two elements are equipped with teeth, the armament of the apparatus. Between these two elements extend the muscles which elevate the mandible and constitute the motive power of the machine. Ordinarily they are spoken of as the muscles of mastication; the *masseter*, the *temporal* and the two *pterygoids;* and then at the front end of the mandible are muscles attached to the genial tubercles to assist in lowering the mandible, the *digastric* and the *geniohyoid*, and the muscle which forms the floor of the mouth, the *mylohyoid*. The cheeks and the lips on the outside serve as the outer walls of the cavity which contains the food while it is being masticated. The tongue on the inside is actively engaged in keeping the food between the crushing surfaces, and assists the cheeks and lips in that way. The last element of the apparatus is the salivary glands, the secretions of which have both a mechanical and physiological function. They lubricate the machine, soften and dissolve the food and agglutinate it for deglutition, besides performing a digestive function in connection with the food.

The several portions of the apparatus will be taken up and discussed a little more in detail. The fixed base, which is the two maxillæ united in the median line, is supported upon the skull by a number of very strong columns or supports. It may be better seen if this base is considered as if it were upside down. There are several of these bony columns, one going inside the orbit and reaching the skull in the median line (*A B*, Fig. 60). There is another one from above the first or second molar going right up through the malar bones and the outer border of the eye (*C M D*). When the skull is viewed from below still another column is seen. This is the pterygoid, which supports the distal end of the dental arch.

The Mandible.—The lower jaw is the movable element, the movable arm. It has the general shape of the letter "U" and the ends of the "U" are bent upward at the end and terminate in the condyloid processes. There are several layers of soft tissues intervening at the joint which are placed there to lessen the shock of mastication, and permit the movement of the joint. Between this point and the anterior end the muscles of mastication are attached. They move the mandible as a lever, one end of which is fixed and constitutes the fulcrum. The muscles are attached between this end and what is the weight end of the lever, the forward portion which does the work. Thus it is a lever of the third class. The fulcrum exists in the temporomandibular joint which is interesting from a mechanical standpoint because it has so much to do with the way in which the mandible can move. The form of the glenoid fossa is a large factor in this. The jaw cannot move backward but it can move forward and downward until it is somewhere near the summit of the eminentia articularis. It can also rotate about a horizontal axis, passing approxi-

mately through the condyles. In considering the manner of movement of the mandible it will be seen how the joint renders these movements possible. Its movement is, of course, limited by ligaments. There is the *capsular* ligament which is thickened at the back into a very thick band, which prevents the jaw from going too far forward. The *external* and *internal lateral* ligaments are really nothing more or less than still greater thickenings of the capsular ligament itself on the outside and inside of the joint respectively which prevent the motion of the jaw laterally.

The other ligaments, the *stylomandibular* and *sphenomandibular,* which are largely thickenings of the cervical fascia, do not have very much to do with the way with which the mandible can move.

Of the muscular apparatus it is quite unnecessary to speak extensively. The *masseter* is the muscle most concerned in the elevation of the jaw, and the *temporal* and *internal pterygoid* aid in this movement. The function of the *external pterygoid* must be kept in mind in that it is attached to the *interarticular fibrocartilage* as well as to the neck of the condyle, and serves to pull them both forward in the forward movement of the jaw.

The direction in which the mandible can move may now be noted. First, the simplest form of movement may be taken up, starting from that position of the mandible in which the teeth are in occlusion. This is the point toward which all the movements of mastication ultimately tend. With the teeth in occlusion, what happens when the mandible is depressed? The *external pterygoid muscle* on each side contracts and pulls its condyle downward and forward. The condyles slide down the walls of the glenoid fossæ. The *digastric* and *geniohyoid* muscles attached to the genial tubercles contract and pull down the front end of the mandible. The effect of these contractions is to carry the front end of the mandible down and the distal ends forward. The mandible does not rotate about a fixed axis, but the condyles are being carried forward at the same time that rotation is taking place. In other words, there is a combination of sliding and of rotation. When the mouth opens the condyles slide forward and downward, and the front end of the mandible is depressed. The mouth could not be opened if the condyles remained in the back part of the fossæ.

There is then a combination of rotation about a horizontal axis passing through the condyles and a sliding motion. It so happens that the front teeth describe what is approximately the arc of a circle while they are sliding and rotating; but the center of that circle is not in the condyles, but considerably back of them.

When the mandible is brought up again to the occlusal position the reverse of this takes place, but Tomes and Dolâmore have found out by tracing a large number of jaws that the path of closing is always a little bit in front of that of opening. Direct opening and closing is a type of movement seen in the carnivora. The condyles

do not slide forward. In the herbivorous animal there is a lateral movement. In that lateral movement one condyle remains in the fossa and the other one slides downward, forward and inward. This type of movement is al o noted in the human jaw. One of the condyles remains in its fossa, the other one being pulled downward and forward by the contraction of the *external pterygoid* muscle of the side. Of course that means that the two pterygoid muscles are capable of independent contraction. The mandible rotates approximately about the center of the stationary condyle. The same occurs when the jaw moves to the other side, as it simply reverses the moving and the stationary condyles.

If both *external pterygoids* contract, the jaw is carried forward or protruded. If they contract independent of the muscles attached to the front end of the mandible there is a protrusion of the mandible. That is a type of movement characteristic to the rodents or the gnawing animals. There is then in the human jaw the possibility of these three distinct types of movements.

Now that the fixed base and the movable arm and the motive power of the apparatus, and the manner in which the mandible, or the movable element may be actuated have been described, the teeth will be discussed from the standpoint of their form and arrangement as suitable to the working of the machine.

A Study of the Human Denture.—In the first place the forms of human teeth are modified or fused cones, as are all animal teeth (Fig. 61). The incisors are cones with a flattened end and may be likened to the form of a chisel. This type of a tooth is especially well developed in the rodents. The canine tooth is more nearly a cone of simple form than any other, although not perfectly circular in cross-section. It is similar in general form to the canine teeth in the carnivora, more like them perhaps in a general way than that of any other animal types, the canine in the herbivora being either lacking or very rudimentary in character.

The bicuspids (the term being derived, of course, from their two-cusped or two-coned character) are, as has been indicated, merely two cones fused together.

The molars, on the other hand, have a number of cones fused together, each cone represented by a cusp; in case of the lower first molar normally five cusps, and the others only three or four.

The teeth are arranged in two arched series, consisting normally of thirty-two teeth, sixteen in each series (Figs. 62 and 63). The actual outline of this arch varies with individuals, but within certain bounds this variation in form has no relationship whatever to its functional efficiency.

The upper arch is larger and overhangs the lower. The upper teeth constitute the fixed base in relation with which the lower teeth move, therefore the upper arch would necessarily cover a larger area in order to permit the movement of the lower over its surface.

On the inside of the teeth is the tongue, on the outside the lips and cheeks. The overhang of the molar and bicuspid series in the rear, and of the incisors in the front of the mouth not only serve the useful purpose of providing a larger area over which the lower jaw may move, but it serves to hold the lips and teeth out of the way and prevents

FIG. 62.—Occlusal surfaces of the upper teeth.

their being caught between the crushing surfaces. On the inside the fact that the lower teeth overlap and pass up the inner sides of the upper teeth serves a similar purpose of keeping the tongue out of the way.

FIG. 63.—Occlusal surfaces of the lower teeth.

One may realize how useful this provision is if one observes a set of artificial teeth in which this overhang is not properly provided, when the wearer will frequently complain that he bites his cheeks. Instances of the same difficulty are seen in mouths with full sets of natural teeth, the cusps of which have worn down, and in which the lower jaw has moved forward to what is designated an edge-to-edge bite. There is

no doubt of the authenticity of the reported case of a well-known man who lost his life through cancer originating in the irritation of the cheek from biting it when the cusps of his teeth had worn off until he had an edge-to-edge bite.

The series of teeth normally present an unbroken surface from one end around to the other; that is, there are no spaces between them, as in some of the animals, particularly the carnivorous animals. Man is the only animal not having diastemata, or spaces between his teeth. This is provided for by the bell-like shape of the crowns of the teeth which do not touch at their necks but at the point of interproximal contact. This contact serves to protect the gum tissue below from injury from the food such as meat and vegetable fibers. If one has experienced what it is in one's own denture to have a flat filling, or none at all, in consequence of which food packs in and produces the long train of uncomfortable results, one will understand how wise is this provision of nature.

Occlusion.—The occlusion of the teeth, to attempt a very offhand definition, is the relationship of their morsal surfaces when the mandible is in the position of the resting bite (Fig. 64). The phrase is used to indicate the relationship of the upper and lower teeth when in such contact that there is a definite fitting together of their surfaces. In the occlusal position the condyles of the mandible are in the most distal part of the glenoid fossæ. When the teeth are in occlusion the muscles extending between the jaws are either in a state of tonic contraction, simply holding the jaw up, or they may be actively contracted, that is, pressing the lower teeth firmly upon the upper ones. This is a rather fundamental position of the jaw. It is a position of equilibrium. It is to this position and from this position that all the various movements incident to mastication take place. In the crushing of the food the jaw tends to return from its various excursions to the occlusal position.

The occlusion of the teeth then means the definite relationship existing between the occlusal or morsal surfaces of the teeth. This must be carefully considered, for in order to understand the machine in motion it must first be studied in repose. Perhaps simplicity will be consulted by dividing the description of the occlusion into that of the incisor teeth, and that of the molar and bicuspid teeth.

As to the incisors, which are flat and wedge-shaped, the upper overhang the lower, the incisal edges of the lower resting normally in contact with the lingual or inside surfaces of the upper teeth. This normal overhang or overbite is approximately one-third of the length of the lower teeth, although of course it is subject to slight variation. The canine tooth is really intermediate in the character of its occlusion between the incisor and the bicuspid series. It partakes of the characteristics of the incisors in that it overhangs the lower teeth, but it is like the bicuspids in having a sharp cusp exactly like the buccal cusps of the bicuspids.

When the teeth have worn down either from having had a very small overbite and short cusps originally, or from the use of coarse food, so that there is an edge-to-edge bite, the machine is by no means as effective as in the arrangement referred to as normal. In the latter case the food is simply pinched off and not sheared off as when the upper incisors overhang.

In the study of the occlusion of the molar and bicuspid series of teeth the occlusal surfaces should be first considered (Figs. 62 and 63). It will be noted that they exhibit two rows of cones with depressions or fossæ intervening between them. On this surface of the bicuspids there is a cone on the inner and outer side. In studying the molars there will be found two cones on the inner and outer sides, except on the third molar where the distolingual cusp may be lacking.

There are then a row of inner and a row of outer cones, with fossæ or little pits intervening between them. There are transverse ridges dividing one fossa from another. The same thing is true of the occlusal surfaces of the lower series of teeth. They have a definite arrangement, a row of outer and a row of inner cusps with fossæ between. However, there is a difference in the shape in these two rows of cusps. The inner ones are rounded in the upper series of teeth and are considerably larger than those in the outer row. Speaking technically, the lingual are larger than the buccal cusps, which are sharp and thin, while the reverse of this is true of the lower teeth. The buccal cusps, or outer cones, are the large round ones; the inner cusps are sharp and thin. The rounded cusps in both series are really the functionating cusps. They are the ones which are received into the fossæ when the teeth are in the occlusal position. If an upper set of teeth is superposed upon a lower, it will be found that the lower buccal cusps occupy the fossæ of the upper series and the rounded lingual cusps of the upper fit into the fossæ in the lower set of teeth.

It is not enough in the normal arrangement that any cusp should fit into any fossa. In normal occlusion there is a definite fossa for each cusp to occupy (Fig. 64). Orthodontists have accepted a simple method of determining when a denture is in normal occlusion. They look to see if the mesiobuccal cusp of the first upper molar occupies the buccal groove of the first lower molar and if so and the other cusps fit into their fossæ, and so on, then the occlusion is correct. If this cusp is in front of or back of the buccal groove then it would not be normal occlusion; there might be an interdigitation of the cusps, but it would not be perfectly normal unless each cusp occupied its own particular fossa.

In an inner view of the denture (Fig. 65), the overlapping of the sharp and thin inner cusps of the lower teeth will be noted, each fitting into a groove or space on the lingual surfaces of the upper teeth. This interdigitation has also another rather interesting advantage, and this is that each tooth of both series, with two exceptions, is opposed by two teeth in the opposite jaw. They do not meet end

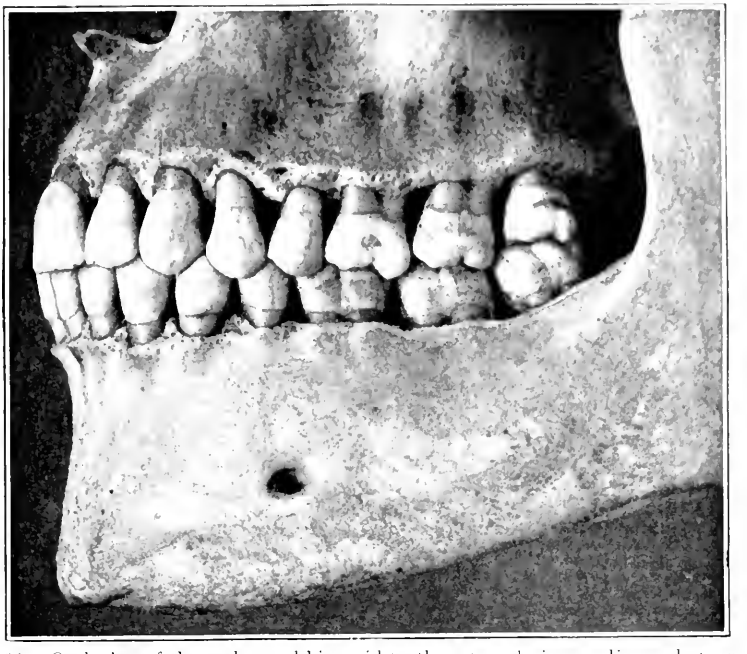


FIG. 64.—Occlusion of the molar and bicuspid teeth, external view. (From photograph of a specimen in possession of Dr. F. A. Peeso.)

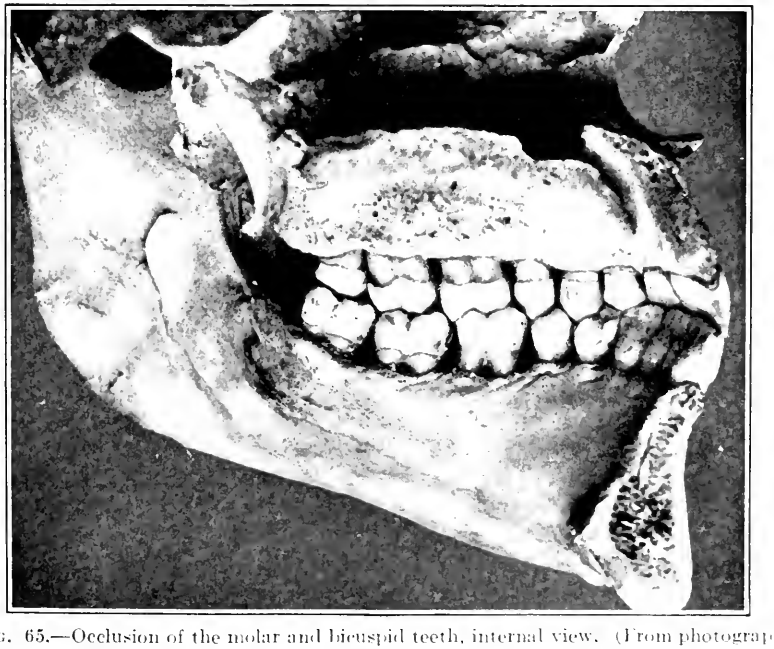


FIG. 65.—Occlusion of the molar and bicuspid teeth, internal view. (From photograph of a specimen in possession of Dr. F. A. Peeso.)

on end, but each tooth is in relation to two teeth. The exceptions are the upper third molar and the lower central incisor which have but one opponent each (Fig. 66).

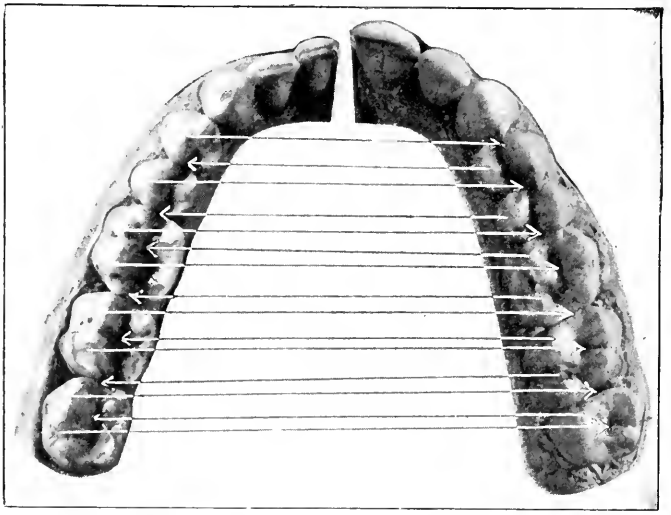


Fig. 66.—Occlusion of the molar and bicuspid teeth, occlusal view. Lines are drawn from the lingual cusps of the upper teeth and buccal cusps of the lower to the corresponding depressions into which they fit. (From photograph of a specimen in possession of Dr. F. A. Peeso.)

Now that the relationship of the morsal or occlusal surfaces of the teeth in the position of occlusion has been described, it will often be referred to as the occlusion of the teeth.

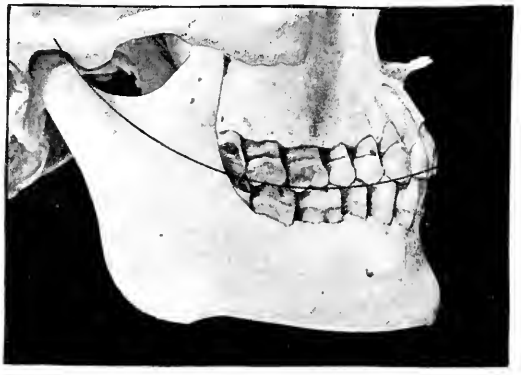


Fig. 67.—The "Curve of Spee." Line passing through anterior face of condyle. (From a photograph of a specimen in the Wistar Institute of Anatomy.)

There are certain other characteristics of the arrangement of the occlusal surfaces of the teeth which are related to what shall be spoken

of as the articulating or active relations of the denture that will be useful when the denture is in motion. One of these characteristics, which is a very important part in the so-called articulation of the teeth, is as follows: If an imaginary line were drawn touching the buccal cusps of the lower series of teeth in a perfect denture, it would be found that they described approximately the arc of a circle, and if it is continued backward under a perfectly typical arrangement, it passes just anterior to the articulating face of the condyle (Fig. 67). Sometimes this line may go a little in front of it, more frequently it is back of the condyle; in a perfect arrangement it passes through the anterior face of the condyle. The same thing is necessarily true of the upper teeth. This is called the curve of Spee. It has been named after von Spee who first called attention to it. This curved arrangement of the occlusal surfaces of the molar and bicuspid teeth has an important bearing on the movement of the mandible.

If two surfaces are to slide one upon the other without interrupting their contact at any point, that is, without being separated at any point, these must be either two perfectly flat surfaces like two panes of plate glass, where one can slide upon the other without admitting air underneath, or else two curved surfaces which are the arcs of the same circle. If they were any other shape, as for example, a parabola or hyperbola, or any irregular curve, they would separate at some point. Now if it were desirable that in the forward-and-backward movement of the mandible all of the lower teeth should slide upon all of the upper at the same time, then these teeth would have to be either in a perfectly plane surface, all absolutely level, or they would have to be arranged around the arc of a circle.

In order to get a clearer understanding of this, it may be supposed that there are no cusps upon the occlusal surfaces and that a curved line represents the top surface of the lower teeth, and a similar curved line represents the occlusal surfaces of the upper teeth. Now if these surfaces are to slide upon each other, without breaking their contact, in the case of the human jaw the mandibular condyles, which of course slide upon the glenoid fossæ, would have to slide in exactly that same curve, otherwise the teeth would be separated at some point.

Now this is the significance of this arrangement of the teeth, that the so-called curve of Spee is always either continuous with the path of the condyle, or it is concentric with it; at any rate they can both move around the same center. This, it must be remembered, is merely a very much simplified example taken to explain the principle involved. These are not plane surfaces, but are cuspid surfaces, and each one of these cusps fits into a fossa. However, it does not take a very great stretch of imagination to see that, though they have cuspid surfaces, the cusps may be arranged so that instead of sliding upon a smooth surface they slide upon the walls of the fossæ into which they fit. That it is possible to have such an arrangement

may be conceived and this is the arrangement in the perfectly typical and typal human denture. Of course the mandible has to be depressed the least bit in order to enable each cusp to slide downward on the front wall of the fossa into which it fits. The cusps slide forward on the walls of the fossæ and back again; and the advantage of this is that every one of the cusps is functionating, is in contact at the same time, not just hitting here or there. But it is possible for a denture to functionate in this fashion only if the teeth are arranged in the manner described.

It will presently be seen, however, that the lower teeth of a normal typical denture cannot slide very far forward without the teeth separating, because the lower incisors strike the lingual surfaces of the

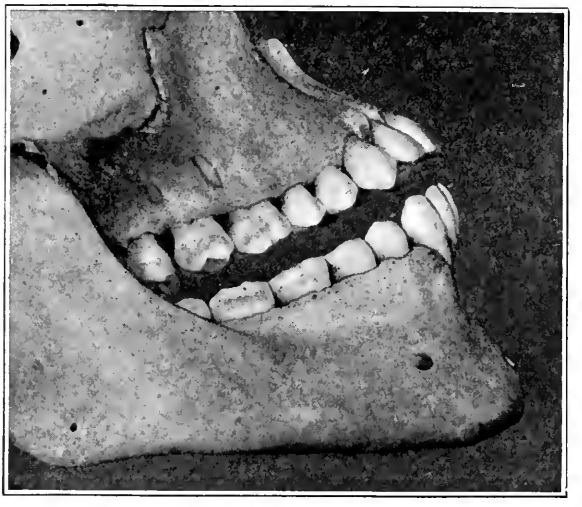


FIG. 68.—Upper and lower bicuspid and molar teeth (side view), showing relative height of buccal and lingual cusps of upper teeth. (From photograph of a specimen in the Wistar Institute of Anatomy.)

upper incisors. After the cusps have moved perhaps half-way up the walls of the fossæ into which they fit, the lower front teeth strike the upper incisors upon which they slide and the distal teeth are separated. But in the return movement, when the lower teeth strike the lingual surface of the upper and slide up until the distal teeth are in contact and then slide back into the occlusal position, each one of the cusps then slides back down the wall of its fossa into the position of the occlusion.

There is another characteristic of the arrangement of the molar and bicuspid teeth which is related to the lateral excursion of the jaw. Taking a typically perfect set of teeth with the jaws slightly apart, it will be seen that, starting from the first upper bicuspid and going toward the rear, the buccal or outer cusps become relatively

a little bit shorter than the lingual cusps and, in the case of the lower teeth, they become a little longer than the lingual cusps. Of the second bicuspid in the upper jaw, the buccal and lingual cusps normally occupy the same horizontal plane. Just in front of it the first bicuspid has a buccal cusp that is longer than the lingual. Returning to the first molar, the buccal cusps are a little shorter than the lingual, and going back farther and farther, they get relatively shorter than the lingual. In other words, the plane of the cusps, instead of being level, gradually curves rootword and outward toward the rear of the denture (Fig. 68).

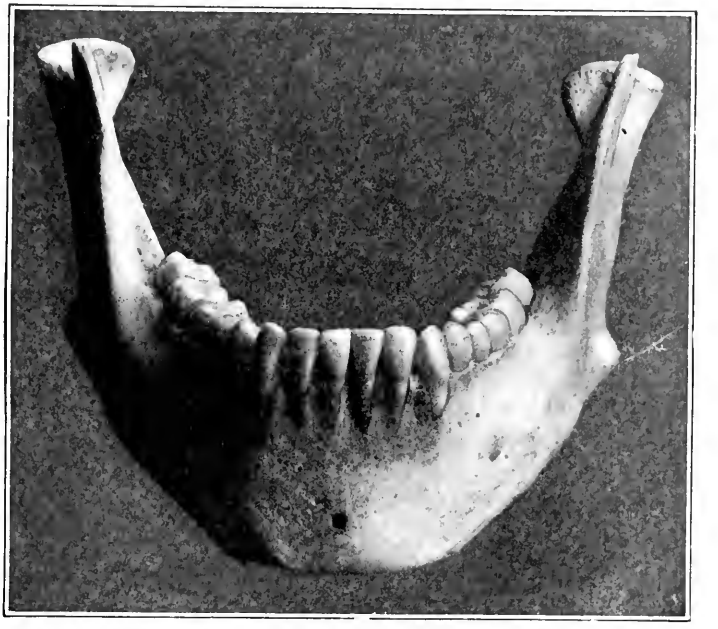


FIG. 69.—Lower bicuspid and molar teeth, front view, showing relative height of buccal and lingual cusps. Same mandible as Fig. 68. (From photograph of a specimen in the Wistar Institute of Anatomy.)

This arrangement can be demonstrated in the mandible although the first bicuspid has a rudimentary cusp or none at all and is atypical in this particular; but farther back the buccal cusps are relatively higher than the lingual until at the third molar they are considerably higher (Fig. 69).

In looking at the upper teeth this characteristic may not be so well illustrated as in the lower jaw, but a gradual tilting out of the long axes of the teeth will be noted. This arrangement is due not only to the height of the cusps, but to a change in the inclination of the teeth. The second bicuspid occupies a perpendicular position; but the teeth back of it gradually tilt outward.

Now what is the relationship of this arrangement to the lateral excursion of the lower jaw? When the mandible is moved to one side with the teeth in contact, if the teeth were arranged so that their cusps occupied the same horizontal plane those on one side would be separated while those on the other side would be in contact. The reason for this is that when the mandible is carried to one side one condyle remains stationary in its fossa while the other is pulled forward and also downward as the surface of the glenoid fossa inclines downward and this side of the jaw must be carried a little lower than the side with the stationary condyle.

If it were not for this difference in the level of the buccal and lingual cusps there would be a lack of contact on the side from which the movement was taking place. In order to compensate for this lowering of the mandible on the side from which the movement has taken place, the two longest or most prominent cusps come into contact; whereas on the other side, the side toward which the movement has taken place, there is a short and long cusp in contact; and it is just the difference between these two which compensate for the downward movement of the jaw on the side from which the movement has occurred (Fig. 70).

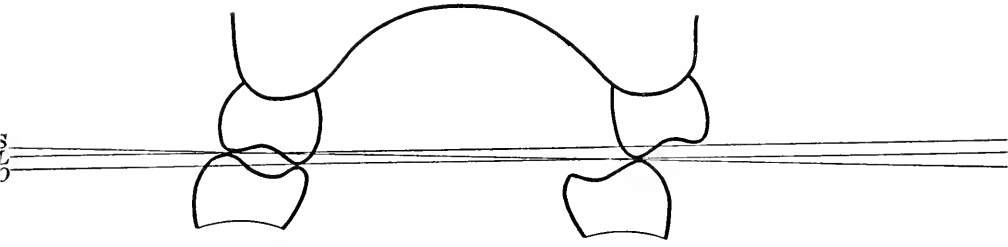


FIG. 70.—Diagram illustrating contact of cusps in lateral excursion of the mandible. Section through jaws at position of second molar. *O P*, line touching lingual cusps of upper molars; *L R*, line touching buccal cusps of upper molars; *S T*, line touching buccal cusps of lower molars, showing the downward movement of the mandible on the right side necessary for contact of the cusps.

What is the advantage of this arrangement? It has exactly the same functional advantage in the lateral excursion of the mandible as the curve of Spee affords in the forward and backward excursion of the jaw; that is to say, it enables both sides to be in contact at the same time. This principle is taken advantage of in making artificial dentures. If both sides of the plates were not in contact at the same time, so that the patient was biting foods on one side with the other side not touching at all, the plates would be thrown down from their base. So it is desirable to imitate the human denture in this particular because it prevents overstrain and provides a denture that is more efficient mechanically.

There is one other detail of the occlusal surfaces of these teeth relating to their function which must be mentioned and this is, that

clearance spaces are provided for the escape of food which has been masticated. The upper row of buccal cusps overhangs the lower, and on the outer walls of all of these fossæ, into which the lower buccal cusps fit, are grooves leading downward and outward through which the food is squeezed. Anyone operating a cutting or grinding machine of any kind will realize the necessity of getting rid of the waste or the chip, as the mechanical terminology is. That is, after the substance has been crushed or ground, there must be an avenue of escape for the waste, and so these grooves, which are not visible on the side view, but which lead downward on the outside of the arch, and upward on the inside, are provided. When the food is crushed between these surfaces it is carried up above the tongue on the inside and downward into the pocket of the cheek on the outside where it may be pressed between the teeth when they are separated for the next crushing motion.

Mastication of Food.—Having described the machine, its mode of operation may now be considered. In the case of man the preparation of food in the mouth does not begin with prehension or gripping of the food, as it does in most of the lower animals. Man has, of course, developed very much beyond that point, and there is no necessity for it. There is no provision for this in his denture therefore, and he has no sharp teeth to prehend the food. The first act of the human animal is to incise; but even incision or the cutting off of appropriately sized particles of food is largely rudimentary in man, since with the development of conventional methods of eating, bringing into use the knife and fork, the incisor teeth are not much exercised. The biting of certain articles of food only is permitted by the usages of polite society. But when incision is indulged in it is rather an interesting mechanical act. The lower jaw is depressed and carried forward, the food is pressed between the lips and upon the incisal edges of the upper teeth, when the lower jaw is carried upward. If the food is very hard, the ends of the upper and lower teeth are almost exactly opposite each other. This direct opposition is absolutely necessary from a mechanical standpoint, in order to bite through hard, resistant food. As soon, however, as the teeth come into contact, or nearly into contact, the mandible is carried backward as well as upward, and the lower incisors slide up the inner surface of the upper, just like the blades of a pair of shears. Then the food is carried back by the tongue to the distal part of the mouth.

In order to understand clearly just what is demanded during trituration of the food, it will be wise to refer again to the importance of a knowledge of the character of the food itself. Its chemical nature is not of so much interest as its physical character viewed purely from a mechanical standpoint. Man's food, broadly speaking, consists of meat fiber, vegetable fiber, grain or cereals and foods made from them and legumes, although the last is not of the same importance as the others. The chief articles which must be pre-

pared for digestion are vegetable and meat fibers, cereals or grain. It is necessary to reduce this food to a condition suitable for passage into the stomach. Its physical consistence must be reduced that it can be acted upon by the digestive ferments and solvents. The crushing of grain, the starchy element of man's food must be very much more extensive than is necessary for the other elements. In the first place, its outer covering has to be removed, or at least broken, and the grains of starch themselves must be so ground up that they can be acted upon by the enzyme of the mouth, and by those farther down in the digestive tract. Mastication of cereals and foods made from them is therefore really much more important than the mastication of other foods.

Baron Oefele has conducted some investigations to show the very poor ability to digest cereals exhibited by people who do not have a full complement of molar and bicuspid teeth. His results are very interesting, but it is only necessary for our purpose to state the fact that he has very conclusively shown the defective digestion of cereals by those whose molar and bicuspid teeth are defective.

Vegetable fibers must be cut up into short lengths and crushed so that they can be readily acted upon by the solvents and digestive ferments. This is more important than the comminution of meat fibers. Many carnivorous animals eat animal flesh in great masses; carnivorous snakes always swallow their prey whole. Nevertheless it is important that meats should be masticated by man in order to break up the consistence of the fiber, and also it should be cut up into small masses to facilitate its passage through the digestive tract and that it may be readily acted upon by the enzymes and ferments

Dr. Black, who has investigated quite extensively the problem of the mastication of the various kinds of foods, is authority for the statement that the up-and-down movements of the jaw, very much like those of the carnivorous animals, are chiefly concerned in the mastication of meats, and that the lateral movements are chiefly concerned in the mastication of cereals and foods made from them.

While it is not true that in the masticating of any type of food one is limited to any particular type of movement, it is a fact that the foods which require the greatest amount of crushing force are masticated in the return from the lateral excursion of the mandible.

When the cereal food is brought into the mouth and carried back to the molar and bicuspid teeth, mastication usually occurs on one side at a time; and if the mouth is in a state of balance and perfect health, it is very apt to occur first on one side and then on the other. The mandible is carried to one side, the cusps are brought into contact, some of the food being cut off on the outside and some on the inside, but a mass remains which occupies the space between the cusps and in the fossæ and on the return to the position of occlusion the cusps slide into the fossæ with a sort of mortar-and-pestle effect. In this movement the greatest crushing ability is exhibited. In

ordinary mastication this lateral movement is combined with direct up-and-down movement. Mastication is not carried on in any precise mechanical order, but all of the movements are combined at times.

Dr. Black has also made in this connection what is rather an interesting table of the amount of force necessary to crush the various foodstuffs. Dr. Joseph Head, of Philadelphia, has also produced a similar table, though using a different method, and the two will be presented together. Dr. Black's experiments were most interesting. He had some brass castings made of the molar and bicuspid series of teeth, upper and lower, and had them arranged in a machine so that the lower could be brought up into contact with the upper by the movement of a hand lever: This simply had the up-and-down motion. He and a party of friends went at various times to restaurants in Chicago, and while they were dining themselves, they gave this automatic chewing machine various tidbits, and registered on it, as they could not on their own jaws, the amount of force necessary to crush the various foodstuffs.

Dr. Head, realizing the value of the lateral excursion, and believing that much less force was required in the crushing of food with this type of movement, made experiments similar to those of Dr. Black, except that he took a human skull with a fine set of teeth and turned it upside down, bored a hole through the skull, and suspended weights from the mandible by means of string or wire. He proved that to accomplish the same amount of crushing, less force was required in this lateral sliding movement. Dr. Black's and Dr. Head's tables are here given.

	Dr. Head's results.	Dr. Black's results.
Raw cabbage	16	40–60
Raw onion	4	
Head lettuce	8	25–30
Radish—whole	20–25	
Radish—pieces	10–25	35–40
Corned beef	18–20	30–35
Boiled beef	3	
Tongue	1–2	3–5
Lamb chops	16–20	
Roast lamb	4	
Roast lamb kidney	3	
Tenderloin of beefsteak (very tender)	8–9	35–40
Sirloin steak	10–20–43	
Round of beefsteak (tough)	38–42	60–80
Roast beef	20–35	35–50
Boiled ham	10–14	40–60
Pork chops	10–13	
Roast veal	16	35–40
Veal chops	12	
Roast mutton	18–22	
Very tough meats	...	90
Hard crusts	...	100
Hard candy	...	250

Dr. Black also experimented with a gnathodynamometer by means of which he could measure the strength exerted by the human dental

mechanism, which for the average was from 150 to 175 pounds. He reported one case in which 275 pounds were recorded on the instrument. He also tried it with persons wearing full artificial dentures, upper and lower, the result being that the average was from 35 to 40 pounds. One may see a vast difference in the amount of crushing ability of natural and artificial teeth.

Mastication is, of course, a voluntary act (speaking physiologically), that is, it begins voluntarily and is continued reflexly and automatically. The food is rolled from one side to the other by the tongue. The teeth functionate first on one side and then on the other. The teeth have exquisite sensibility. It is through them that sensations are received that indicate the amount of chewing necessary to give any given mouthful, and also through them in conjunction with the tongue as to whether the food has been thoroughly triturated or not. After it has been thoroughly masticated it is rolled up into a bolus on the tongue, the tip of which is elevated, and by contraction of the muscle of the floor of the mouth, the mylohyoid, the food is forced back into the esophagus.

The secretion of the saliva, while constantly going on in the mouth, is tremendously increased when any foreign substance, like food, is put into the mouth. The working of the muscles moving the jaw probably also increases the flow of saliva. The saliva serves to lubricate the various portions of the apparatus which are in the mouth. It contains a ferment, ptyalin, which has some digestive usefulness. The water in the saliva dissolves some of the food, and as it also contains mucin, the latter helps to agglomerate the mass and to lubricate it so that it is finally easily swallowed.

The teeth are equipped with means of resisting the wear incident to the activity of this mechanism. The enamel is the outer envelope of the crowns of the teeth and is the hardest structure in the human body. It is of course necessary to have a very hard covering for the teeth to enable them to resist the wear incident to their long use. Under present conditions of civilization, where comparatively little mastication is necessary, not a great deal of wear of the teeth occurs. The teeth of prehistoric man, and, indeed, of our own aboriginal races, wore very badly from the coarse character of the food. Any collection of skulls of North American Indians which one may happen to see at once impresses one with the great amount of wear of these teeth. Of course this is due, not only to the rough character of the food, but also to the fact that Indian corn, a staple diet, being ground in stone mortars had fine particles of stone or silica mixed with it, which serve to grind the teeth down.

Anatomists have recognized several degrees of wear. No one reaches the age of twenty-five without beginning to show some evidence of wear of the teeth. A little later the second degree is reached, where the enamel is worn through and the dentin exposed, and the cusps are really beginning to wear down a little; or it may even, under

conditions of our civilization, get to the third degree, where the cusps are all worn away and the teeth are reduced in height.

Mastication has also a beneficial influence upon the teeth. The friction of the food exerts a cleansing influence as regards colonies of bacteria and deleterious food particles upon their surface. Disuse of the teeth on the other hand, greatly increases the deposits of salivary calculus and sordes upon the teeth. Often upon looking into a mouth it is perfectly easy to judge upon which side a crippled tooth exists, because when the chewing is done on the other side, exclusively, deposits on the teeth of the crippled side identify it.

The use of the denture in mastication also exercises the peridental membrane. As the teeth move up and down in their sockets, blood

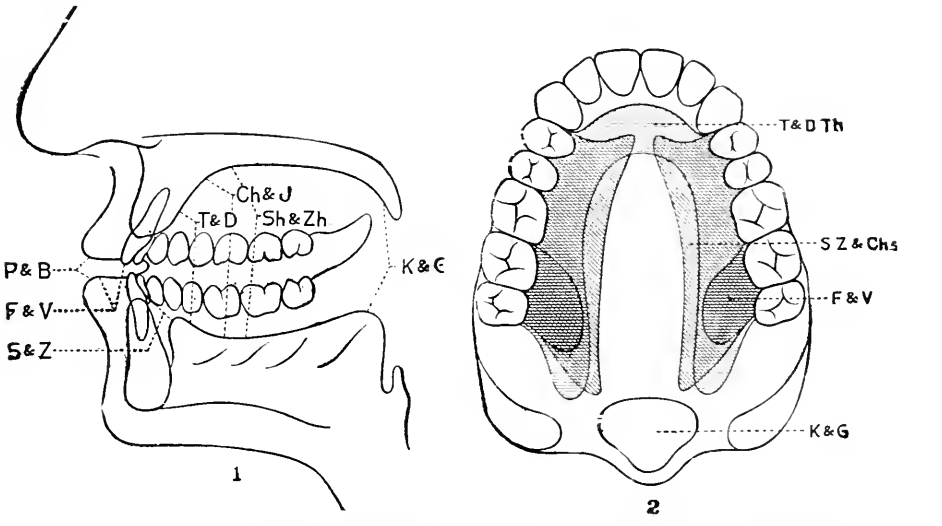


FIG. 71.—*1*, diagrammatic drawing, showing place of articulation of the consonant sounds; *2*, drawing showing contact of the tongue with molars and bicuspids in the formation of certain consonants.

is pumped in and out of this tissue and thus it is kept in a healthy condition and degeneration of the pericementum is deferred if not prevented.

Supplementary Functions of the Teeth.—In conclusion, certain secondary functions of the teeth will be briefly considered. They participate in the activity of the mechanism concerned in the production of speech. The lips and tongue with the teeth and the contiguous portions of the alveolar process are the most important factors in the production of consonant sounds. Thus the "F" and "V" sounds, for example, are pronounced by the sudden escape of air between the lower lip and the upper front teeth. It is unnecessary to go into this detail at length, but an allusion is made to it as an additional reason for care in the preservation of the teeth (Fig. 71).

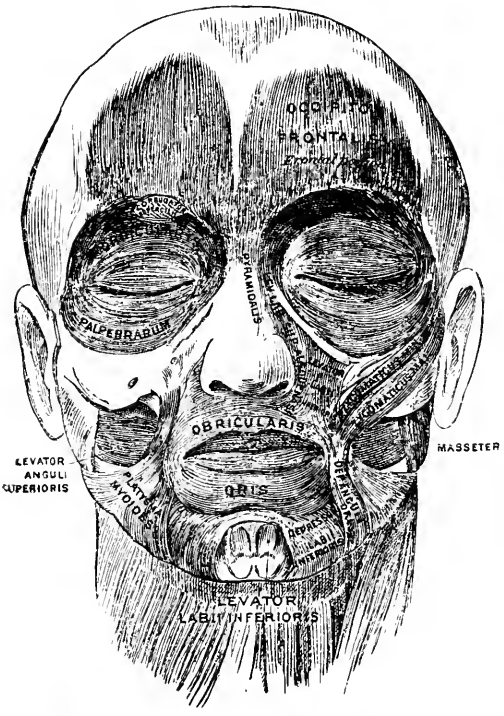


FIG. 72.—The facial muscles of expression.

FIG. 73.—Photograph, showing effect of the loss of the teeth upon the mouth, and wrinkles established thereby.

FIG. 74.—Photograph, showing the effects of the loss of the teeth upon the profile.

They are also passive elements in the mechanism concerned with the facial movements of expression, which are movements of the facial muscles that either supplement language or convey ideas or emotions or states of mind.

The underlying structures in this mechanism are the skull and the teeth, overlying which are soft tissues including the facial muscles of expression. There is a large group of these centering around the mouth which makes it one of the most expressive features of the face. These muscles are superficial, converge toward the mouth and terminate in one big muscle, the orbicularis oris, of which latter the lips are chiefly composed. These are all supported beneath by the teeth and the alveolar process, over which as a sort of base they are moved by these various muscles. In some of these movements the lips are parted so that the teeth are disclosed. Both pleasurable and painful emotions may be so expressed (Fig. 72).

Finally the teeth serve to support the lips and the cheeks and thus take part in the maintenance of the fixed expression of the face. Their loss is attended by a falling in of these tissues, an approximation of the jaws, and by a marked change in the appearance in the face. To guard against this "last scene of all" is the final reason for their preservation (Figs. 73 and 74).

CHAPTER IV.

MALOCCLUSION OF THE TEETH.

By RODRIGUES OTTOLENGUI, M.D.S., D.D.S., LL.D.

If the mouth hygienist, besides preserving the health of her charge, would aim likewise to guard against the attacks of disease, it is evident that she should have knowledge of such diseases as may prove a menace in her particularly field of work, and she should likewise learn to recognize these diseases in their incipient stages that she may refer the patient for treatment before the ravages prove serious.

Therefore, in presenting the subject of malocclusion, let us consider for a moment how dental caries is aggravated by irregular or malposed teeth.

DENTAL CARIES.

Areas of Susceptibility.—Students of the subject tell us that in the vast majority of cases caries begins in certain definite localities. Thus caries upon the masticating surfaces of bicuspids and molars first appears in the sulci or fissures between the enamel plates. Between the teeth or, as we say, on the approximal surfaces, caries has its initiation at, or just gingival to, the approximal contact points. While it may not be absolutely true that "a clean tooth never decays," it is true than an unclean tooth is more vulnerable than one that is clean. It follows, therefore, that the unclean or uncleansable parts of a tooth are more likely to decay than the clean or readily cleansable parts of a tooth, and this is in consonance with the statements above made as to the locations where caries usually begins, because the sulci of molars and bicuspids, and the approximal contact points of all teeth, are the localities in which food débris is most apt to lodge and most difficult to dislodge. Another region in which caries often occurs is upon the labial and buccal surfaces of teeth immediately near the gum line. Here the seepage of mucus agglutinizes the food débris and the overhanging gum margins protect the accumulations from the natural cleansing agents. Still another place is in the grooves on the buccal surfaces of the molars, which are analogous with the sulci upon the masticating surfaces. These, then, are to be counted the vulnerable places.

Areas of Immunity.—The lingual surfaces of all the teeth, swept as they are by the tongue, constitute the most immune areas, though occasionally we find pits or crevices in the upper incisors, which because they are pits or crevices become susceptible points. The

labial surfaces of all incisors and cuspids, except at or along the gum margins, and the buccal surfaces of all bicuspids and molars, exept in the molar buccal grooves and along the gum margins, are practically immune to caries.

So we find that there are certain localities which are vulnerable and other definite parts of the tooth which are practically immune to caries. Also, that this immunity is closely related to the possibility of cleansing these areas.

Between these vulnerable and immune locations are areas of comparative immunity, this comparative immunity increasing toward the immune or most easily cleansed part, and decreasing as we approach the vulnerable or less easily cleansed part.

Caries and Malocclusion.—Thus we arrive at the important relation between malocclusion and caries. We have seen that certain parts of the teeth are counted to be immune to caries, and that adjacent to these areas are other parts which are comparatively immune. But this is true only when all the teeth are in normal relationship one with the other, which in effect means when all the teeth are in normal occlusion.

Malocclusion may not perhaps often increase the vulnerability of the occlusal surfaces of the teeth, though at times it may even have this effect; but malposition of the teeth will frequently increase the vulnerable approximal areas by increasing the contactual areas beyond the normal; and it will likewise lessen the immunity of the immune and comparatively immune areas, by rendering cleansing more difficult and at times even impossible.

We will better comprehend this by the examination of a skull where we may see the teeth and bones freed from the soft tissues.

Interproximal Spaces.—Fig. 75 affords a good example of normally occluded teeth, one maxilla and one-half of the mandible with their teeth being shown. Attention should be called first to the spaces between the teeth known as interproximal spaces. Note that these are, generally speaking, trangular in shape, the base of the triangle being along the border of the alveolar bone, the sides of the triangle being the approximal surfaces of the adjacent teeth, and the apex at the point of contact of the two teeth. Select any approximal space distal of the cuspids and note that the apex of the cusp of the antagonizing tooth of the opposing jaw falls immediately opposite the center of this interproximal space, the obvious tendency being to force food between the teeth, and into this interproximal space. Hence the need of the contact point. Passing from the study of these bones and examining a living specimen, we would observe that this interproximal space is filled with gum tissue, this particular part of the gum being denominated the septum. This septum, filling as it does a triangular space, is conical in shape and is thicker than other parts of the gum. For this reason its outer surface is farther away from its bony support and consequently it is more easily injured than

the gum elsewhere. This is an added need for close contact of the adjacent teeth, as a protection to this sensitive tissue from the impaction of food and the retention of it, if forced into the interproximal space. The student should note also that the gum septum, also called the gingiva, even in the healthiest subject, does not entirely fill the interproximal space, so that commonly there is a small but actual space between the approximal contact points and the septum or gingiva. It is because of this fact that approximal caries often has its inception just gingivally of the contact point, since it is just in this space which is protected from the natural cleansing agencies that débris may collect and remain.

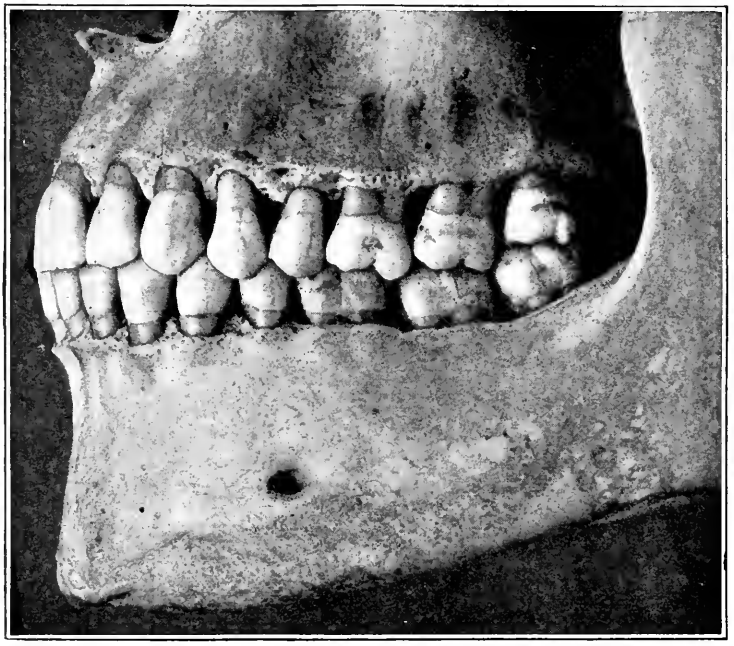


FIG. 75.—Occlusion of the molar and bicuspid teeth, external view. (From photograph of a specimen in possession of Dr. F. A. Peeso.)

If we study the matter more closely still, we must see that wise provision has been made for the exclusion of foodstuffs from the interproximal spaces. True, the grinding cusps of the masticating teeth, falling as they do exactly opposite to the entrances to the interproximal spaces, would seem to be advantageously situated for the forcing of food into these spaces, yet this accident is well guarded against. First we find that the cusps in typically formed teeth occlude with the mesial and distal marginal ridges of the two teeth with which each cusp normally antagonizes. These marginal ridges have

planes sloping toward the central portions of the masticating surfaces, and hence away from the interproximal space.

Moreover we find sulci serving as sluiceways to lead the food, during maceration, lingually and buccally away from the spaces between the teeth, and consequently it should require more force to crowd the food into the interproximal spaces than away from them into and out of the sluiceways. Additional protection of the gingivæ is to be found in the form and position of the contacts, as well as in the form of the septum itself. The contacts are closest occlusally and triangular in shape so that the width of the contacts increase slightly toward the gingiva, while the approximal surfaces of the teeth, curving rapidly apart, afford ample opportunity for the escape of food, especially as the septum itself is conical and full enough bucco-lingually to extend somewhat beyond the actual interproximal space and thus aid in receiving and carrying the food away from, rather than into, the space.

All this may seem somewhat complex, whereas in reality when once fully comprehended, it will be seen to be quite simple and as admirable an arrangement as it is a simple one. Yet its efficiency depends entirely upon and is proportional with its typical normality. Any aberration from the typical in the formation of the teeth, and any departure from the normal in the position of the teeth, must proportionately destroy the balance between the several factors which, when present and working in unison, will afford ample protection to even this vulnerable locality.

Contact Point in Normal Arrangement.—Glancing again at Fig. 75, the student is asked to note that the teeth being in normal arrangement, the contacts are at a minimum, while yet being sufficient to afford protection. Since caries starts at these points of contact, it must be manifest that any malposition of the teeth which will bring into contact a greater area than normally should be in contact, not only increases the actual area of the vulnerable region, but by altering the protective form of the contact points, must necessarily add also to the vulnerability. In Fig. 75 note also that as each tooth is in its normal pose the greater portion of its exposed surface is brought into symmetrical alignment with its neighbors, so that any cleansing agency sweeping around the arch would come into touch with and consequently would cleanse the greatest width of such surface. Thus, where teeth are normally placed, a brush passing around the arch would cleanse nearly all the labial and buccal enamel, while a brush passed vertically over these surfaces would cleanse them entirely. An examination of the lingual surfaces (Fig. 76) discloses the fact that the truly normal arrangement again brings beneath the influence of a cleansing agent the widest expanse of surface.

It is equally evident that any malposition of even a single tooth must interfere with this cleansing effort. If a tooth be turned upon its axis, then a smaller part of its labial or buccal surface can be

swept by the brush when the brush is used upon that part, and the same would be true when brushing the lingual surfaces. If a tooth extends beyond its neighbors, either buccally or lingually, not only will it become more difficult to cleanse that particular tooth, but its position must interfere more or less with the cleansing of its neighbors.

It is seen then that any aberration from the normal in the interrelation of the teeth renders them more difficult to keep clean, but it must be understood that aside from the artificial cleansing which is to be accomplished with brushes, powders, etc., the typical forms and arrangement of the teeth are such that the normal use of these organs leaves them moderately clean, so that the teeth in ideal normal occlu-

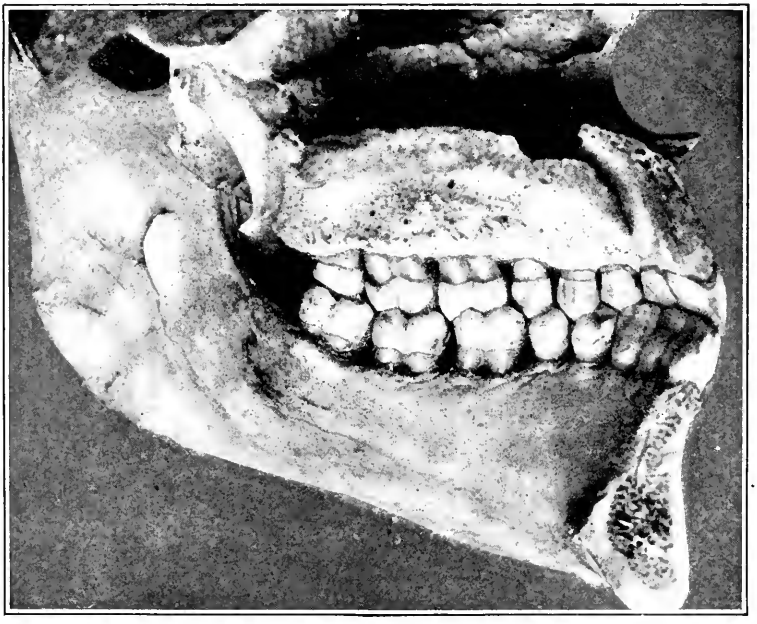


FIG. 76.—Occlusion of the molar and bicuspid teeth, internal view. (From photograph of a specimen in possession of Dr. F. A. Peeso.)

sion are said to be "self-cleansing," this cleansing being accomplished by the lips, the tongue, and by the food passing over the surfaces of the teeth.

Terms Defined.—*Occlusion:* The relation between the upper and lower teeth when the jaws are closed.

Arch: A term used to designate the upper or lower teeth collectively.

Inclined Plane: The sloping surface of a cusp.

Mesial, Distal: Position is considered in relation to the median line or center of the dental arches. Hence, "mesial" means toward or nearest to the median line, and "distal" means away from or farthest from the median line.

Model: A reproduction of the dental arch or arches made in plaster of Paris.

Labial: Toward the lips.

Buccal: Toward the cheek.

Lingual: Toward the tongue. This term is used to describe the upper as well as the lower teeth.

Protruding: The tipping of the axis of a tooth so that the crown projects labially to normal.

Retruding: The tipping of the axis of a tooth so that the crown slants lingually to normal.

A STUDY OF NORMAL OCCLUSION.

Before the student can comprehend any description of malocclusion he must acquire a knowledge of normal occlusion. He should be able mentally to visualize a set of teeth in normal occlusion, as a standard picture with which to compare any set of teeth under examination, in order instantly to detect deviations from the normal.

Definition.—Normal occlusion is the normal relation of the occlusal inclined planes of the teeth when the jaws are closed (Angle).

As occlusion means the relation between the upper and lower teeth when the jaws are closed, it follows that normal occlusion means that all the teeth in both arches are so situated that they may best perform their functions, and that their interrelation shall be typical and therefore normal.

In a set of teeth in normal occlusion the teeth themselves are arranged in symmetrical parabolic curves, commonly called arches. This means that if a line be drawn across either arch, so as to touch the distal surfaces of the last molars, and a second line be drawn at right angles thereto and through the median space, or between the central incisors, then any two similar teeth on opposite sides of the arch (as for example the first bicuspids) will be equidistant from this central line.

Perhaps the next most noteworthy fact is that the upper arch is slightly larger than the lower, and that the outer cutting edges and cusps of the upper teeth droop over and consequently hide in part the similar portions of the lower teeth when the jaws are closed (Fig. 75). This latter condition is called the "overbite."

In full denture there are thirty-two teeth. In the illustration which depicts one-half of an upper and lower jaw we should see sixteen teeth; but, as a matter of fact, the artist in endeavoring to expose the full surface of the upper central incisor has so turned the subject that in the lower arch we see an extra tooth, the lower central incisor of the opposite side. Mentally eliminating this extra tooth, by studying the illustration we observe that the smallest incisor is the central incisor in the lower arch, while the smallest molar is the last or third molar in the upper arch. It is in accordance with Nature's wonderful design, which aims to produce the highest efficiency in the use of the

teeth collectively as a masticating apparatus, that this is true, for by this means every other tooth except these four occludes with two others. Again glancing at the illustration we see that the lower lateral incisor is in contact with the upper central and lateral; the upper central touches the lower central and lateral; the upper lateral antagonizes the lower lateral and cuspid, and so on around the arch, each tooth of either upper or lower jaw occluding with two teeth in the opposing jaw. The most important usefulness of this arrangement is seen when we consider those teeth which have cusps. For example, observe the first upper bicuspid, occluding with the cuspid and bicuspid of the lower arch. Any food caught in this locality is triturated between three powerful cusps, a much more effective plan than were each tooth to strike only one antagonist, as sometimes occurs where malocclusion is present.

This at once brings us to one diagnostic point. It being a fact that in normal occlusion all the teeth except the lower central incisors and upper third molars occlude so that each tooth antagonizes two, we note that the only place in the entire denture where the interproximal spaces coincide is at the median line. Two facts then may be remembered. Whenever any interproximal spaces above and below coincide (except these at the median line), malocclusion exists. Conversely, whenever the spaces at the median line do not coincide, malocclusion is present.

We should next consider those teeth which are supplied with cusps, viz., the cuspids, the bicuspids and the molars. In regard to the cuspids and bicuspids, when in normal occlusion the crest or extreme angle of the cusp should be exactly in line with the interproximal space between the two teeth with which it occludes. Or to phrase it differently, a line drawn through the central axis of a cuspid or bicuspid should pass between the two antagonizing teeth.

In all the teeth which have cusps, including the molars, each cusp has four slanting surfaces called inclined planes; note that of these the mesial inclined planes of the cusps of the upper teeth occlude with the distal inclined planes of the cusps of the lower teeth; and of course the distal inclined planes of the upper cusps touch the mesial inclined planes of the lower teeth.

As will be seen presently, however, a point of extreme significance, because used so often as a basis of diagnosis, is the occlusal relation of the upper and lower first molars. The student therefore should become thoroughly familiar with this cusp relation (Fig. 75). The upper molar has two buccal cusps, known as the mesio-buccal cusp and the disto-buccal cusp. In normal occlusion the mesio-buccal cusp of the upper first molar occludes between the mesio-buccal and buccal cusps of the lower first molar, in such a manner that the crest or extreme point of the cusp coincides with a groove in the buccal surface of the lower tooth, known as the buccal groove. It is well also to observe that the mesio-buccal cusp of the lower molar occludes in

part with the similar cusp of the upper molar and in part with the upper second bicuspid; also that the extreme mesial surface of the lower molar is on a line with the central axis of the upper second bicuspid. Attention is called to this fact here, as it will be again elsewhere, because while in the normal relation the lower first molar is slightly mesial of the upper first molar, it should not be farther forward than the median axis of the upper second bicuspid.

A study of the same set of teeth from the lingual aspect (Fig. 76) shows similar interlocking of the teeth and the general appearance is the same except that here it is the cusps and incisal ends of the upper teeth that are slightly hidden in consequence of the overbite, the converse of what is true of the buccal view (Fig. 75).

Summary.—1. Where teeth are in normal occlusion they are arranged in symmetrical parabolic curves and any two similar teeth on opposite sides of an arch will be equidistant from the central line, or axis.

2. The upper arch is larger than the lower and the cusps of the upper teeth droop over the lower. This is denominated the overbite.

3. With the exception of the two lower central incisors and the two upper third molars, each tooth in each arch antagonizes with two teeth of the opposite arch when in occlusion.

4. The interproximal space at the median line above and below should coincide. When they do not, or when any other interproximal spaces do coincide, a malrelation of the arches is present.

5. A line drawn vertically through the median axis of any cuspid or bicuspid should pass between the antagonizing teeth.

6. The mesial inclined plane of any cusp occludes against the distal inclined plane of the opposing cusp; the converse therefore is likewise true.

7. In normal occlusion the mesio-buccal cusp of the upper first molar occludes between the mesio-buccal and buccal cusps of the lower first molar.

MALOCCLUSION.

Definition.—Any deviation of the teeth or arches from normal relation is termed malocclusion.

Malocclusion of Individual Teeth.—A tooth may occupy any one of seven malpositions, and it is even possible for it to be malposed in four ways.

These malpositions have been named as follows (Angle): (1) Labial or buccal occlusion; (2) lingual occlusion; (3) mesial occlusion; (4) distal occlusion; (5) supra-occlusion; (6) infra-occlusion; (7) torso-occlusion.

1. Labial or buccal occlusion means that a tooth crown is so malposed that it is labial or buccal of its true normal position.

2. Lingual occlusion means that a tooth crown is so malposed that it is lingual of its true normal position.

3. Mesial occlusion means that a tooth crown is mesial of the position which it should normally occupy.

4. Distal occlusion means that a tooth crown is distal of the position which it should normally occupy.

5. Supra-occlusion means that a tooth has erupted to an abnormal height in its socket.

6. Infra-occlusion means that a tooth has not erupted to a normal height in its socket.

7. Torso-occlusion means that a tooth is turned in its socket so that it does not occupy its normal place in the arch alignment.

In explanation of the statement that a single tooth may be in four positions of malocclusion at one and the same time, I would cite the following example: A molar tooth may be in torso-occlusion; in buccal or lingual occlusion; in mesial or distal occlusion; in supra- or infra-occlusion.

Classification of Malocclusion.—It is manifest, therefore, that there are endless varieties of malocclusion when viewed in the light of single or multiple malpositions of the individual teeth. It remained for Angle, however, to discover the possibility of formulating a classification for malocclusion, independent of these individual malpositions but based upon the relations of the two arches considered as units. Other writers have endeavored to erect classifications which do depend upon the individual malpositions, but in none of these is the line of demarcation between the described classes so well drawn that it may serve as an absolute division between the multiplicity of conditions that arise. The result is that often cases are found which might fall into either of two such classes or even into both. For example, we have had classes for "outstanding cuspids"—cases where the cuspids have erupted labially of normal. Again, classes of "open bite," meaning an infra-occlusion or lack of antagonization of the incisors. What are we to do then with a case where we have "outstanding cuspids" complicated with "open bite?" In the Angle classification no such confusion can occur. His lines of demarcation are so distinct, that there can be no lapping of boundaries.

Of his classification Angle writes:[1] "These classes are based on the mesio-distal relations of the teeth, dental arches and jaws, which depend primarily upon the positions mesio-distally assumed by the first permanent molars on their erupting and locking. Hence, in diagnosing cases of malocclusion we must consider first, the mesio-distal relations of the jaws and dental arches, as indicated by the relation of the lower first molars with the upper first molars, the keys to occlusion; and second, the position of the individual teeth, carefully noting their relations with the line of occlusion."

Angle then has divided all malocclusion into three great classes dependent upon the mesio-distal relations of the arches considered

[1] Angle, Seventh edition, p. 35.

as units. It is evident, then, that to make a diagnosis, we must always begin with a picture of normal molar occlusion in the mind, and with the question, "Is the mesio-distal relation of the molars normal on both sides?" The answer to this mental question will invariably classify the case.

To have such a mental picture we must carefully study normal molar relations, as shown in Fig. 75, noting that the mesio-buccal cusp of the upper first molar occludes with the lower first molar in such a way that a line drawn through the apex of this cusp will fall directly into the buccal groove of the lower molar. Or to phrase it differently, the mesio-buccal cusp of the upper first molar occludes between the mesio-buccal and buccal cusps of the lower first molar, whereas the mesio-buccal cusp of the lower first molar occludes between the mesio-buccal cusp of the upper molar and the buccal cusp of the upper second bicuspid. Thus we see that the mesial surface of the lower first molar is normally slightly mesial to the corresponding surface of the upper first molar. Hence, in studying mesial occlusion of the lower first molar, it is important to recognize the limitations of the normal mesial position of this surface in relation with that of its antagonists. When the cusps are not mutilated by caries or bad fillings, however, we may confine ourselves to an examination of the cusp relations.

The Angle Classification.—In studying a case, if we find that the mesio-distal relations of the upper and lower first molars on both sides are *normal*, the malocclusion belongs in Class I.

If the *lower first molar* on one or both sides is found to be *distal* to normal in relation with the upper first molar, it is said to be in distal occlusion, and the malocclusion falls into Class II.

If the *lower first molar* on one or both sides is found to be *mesial* to normal in relation with the upper first molar, it is said to be in mesial occlusion, and the malocclusion falls into Class III.

The distinctions, therefore, between Classes I, II and III are very definite and should be readily comprehended. Some confusion has been caused in the minds of beginners by the fact that there are divisions and subdivisions, but these likewise may be so plainly described that there should be no difficulty whatever. Once having learned to distinguish between Classes I, II and III, we next learn that there are no divisions in Class I nor in Class III. But Class II is separated into two divisions: Division 1, wherein the upper incisors *protrude*, and Division 2, wherein the upper incisors *retrude*. These are the sole factors by which the divisions of Class II are determined, and there remains no more to learn except the subdivisions. A subdivision is any case of malocclusion where the mesiodistal relations of the upper and lower first molars is *normal on one side and abnormal on the other*. If the abnormality be a distal occlusion, the case must be a subdivision of Class II, because all cases of distal occlusion are in Class II. If the abnormality be a mesial occlusion the malocclu-

sion must belong to Class III because all mesial occlusions are in Class III.

The following recapitulation of the classification is copied from Angle, omitting his references to etiological factors with which we are not at the moment interested:

Class I. Arches in normal mesio-distal relation.

Class II. Lower arch distal to normal in its relation to the upper arch.

Division 1. Bilaterally distal, protruding upper incisors.

Subdivision. Unilaterally distal, protruding upper incisors.

Division 2. Bilaterally distal, retruding upper incisors.

Subdivision. Unilaterally distal, retruding upper incisors.

Class III. Lower arch mesial to normal in its relation to the upper arch.

Subdivision. Unilaterally mesial.

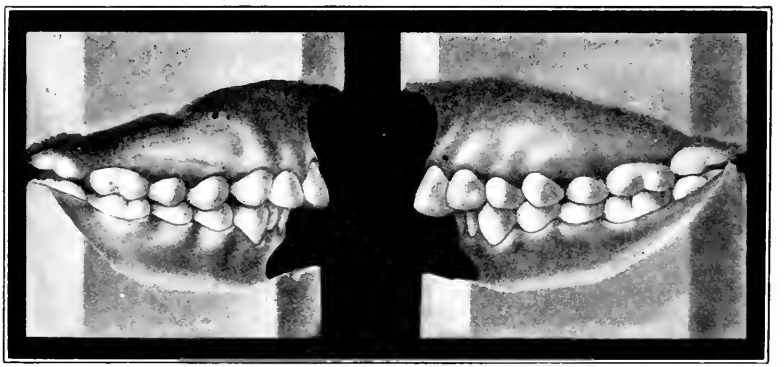


FIG. 77.—Models of a case of malocclusion, Class I.

To fix the differentiations of this classification more firmly in the mind let us examine the illustrations of a few typical cases. In Fig. 77, an examination of the first molars discloses that on each side the mesio-distal occlusal relations are normal. On each side the mesio-buccal cusp of the upper first molar occludes between the cusps of the lower first molar, and a line drawn through the central axis of the mesio-buccal cusp of the upper molar, strikes the buccal grove of the lower first molar. This, then, discloses a bilateral normal mesio-distal occlusion of the arches, and the malocclusion consequently falls into Class I. For this illustration a case where the upper incisors protrude has been selected, that by comparison the student may better grasp the difference in the significance of protruding incisors in Class I and Class II, Division 1.

In Fig. 77, the normal mesio-distal relations of the first molars definitely fixes the case in Class I. Hence the protrusion of the upper incisors *has no significance* in connection with the classification of the case.

In Fig. 78, an examination of the molars shows that the lower molar on each side is in distal occlusion. The mesio-buccal cusp of the upper first molar does not coincide with the buccal groove of the lower first molar, but on the contrary falls between the mesio-buccal cusp of the lower molar and the buccal cusp of the second bicuspid. The case

FIG. 78.—Malocclusion: Class II, Division 1.

therefore falls into Class II, and *since the upper incisors protrude*, it must be in the *first division* of that class. Being *bilaterally distal, with the upper incisors protruding*, it belongs to Class II, Division 1.

In Fig. 79, we see a case quite like the last, and superficially like Fig. 77, but a study of the molars shows a *distal occlusion on one side* and *normal mesio-distal relations on the other*. And as the *upper incisors protrude*, it is placed in Class II, Division 1, Subdivision.

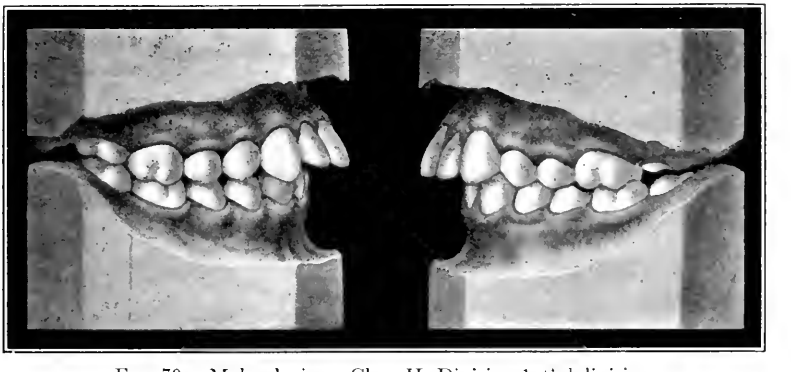


FIG. 79.—Malocclusion: Class II, Division 1, Subdivision.

It is in Class II, because there is a distal occlusion; it is in Division 1, because the upper incisors protrude. It is a Subdivision because the distal occlusion is confined to one side. It is therefore unilaterally distal with protruding upper incisors.

In Fig. 80, we find both lower first molars in distal occlusion. The

case therefore belongs to Class II, which includes all distal occlusions. We note that the *upper central incisors retrude*, for which reason the case belongs to Division 2. It is therefore a case belonging to Class II, Division 2, because it is bilaterally distal with upper incisors retruding.

In Fig. 81, we see a case strikingly like the last, except that on close examination we find that the distal occlusion is confined to one side,

FIG. 80.—Malocclusion: Class II, Division 2.

for which reason it must be a subdivision case. It belongs, therefore, to Class II, Division 2, Subdivision, being unilaterally distal with retruding upper incisors.

In Fig. 82, we find the lower first molars mesial to normal. Indeed, they are so far mesial that they have lost all occlusal contact with the upper first molars, so that the classification is very simple. The case

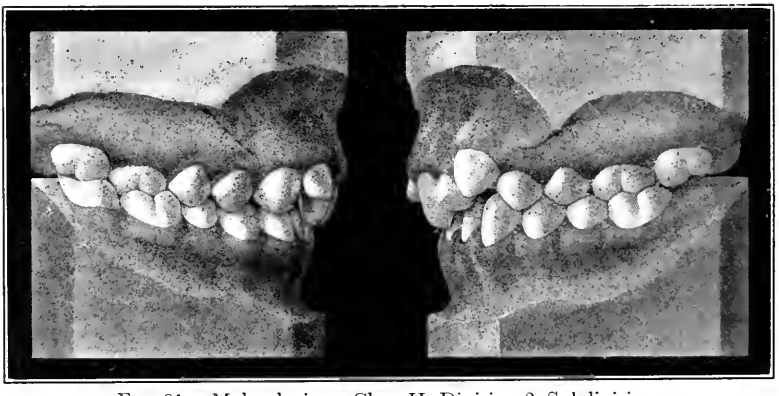


FIG. 81.—Malocclusion: Class II, Division 2, Subdivision.

must belong to Class III, which includes all mesial occlusions. An extreme case has been selected for this illustration, but the actual normal mesio-distal relations must always be in the mind as a mental picture with which the case in hand may be compared, and in the presence of the full complement of permanent teeth, if the lower molar is found to be mesial to normal, the case belongs to Class III.

Observe, however, the qualification "in the presence of the full complement of the permanent teeth." The premature loss of a temporary molar, or the extraction of a bicuspid may permit a lower first molar to drift abnormally forward, presenting a confusing picture. It is always to be remembered, therefore, that this entire classification is

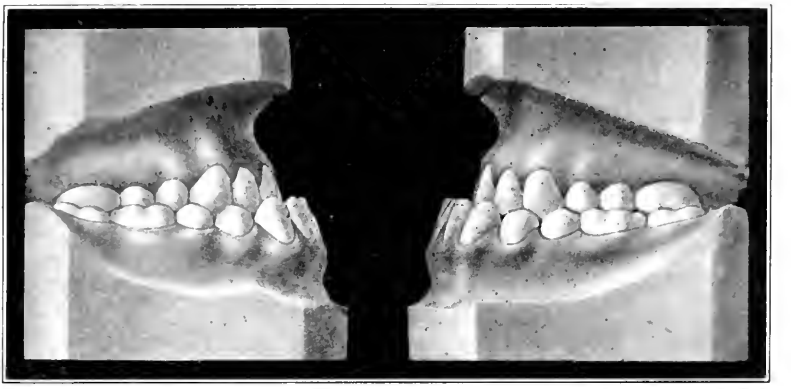


FIG. 82.—Malocclusion: Class III.

dependent upon the presence, or space for the eruption of, all the permanent teeth, and the drifting of teeth due to extractions or loss of temporary teeth is always a matter for separate consideration.

In Fig. 83, we find a mesial occlusion on one side, and a normal mesiodistal relation on the other, for which reason the case belongs to Class III, subdivision.

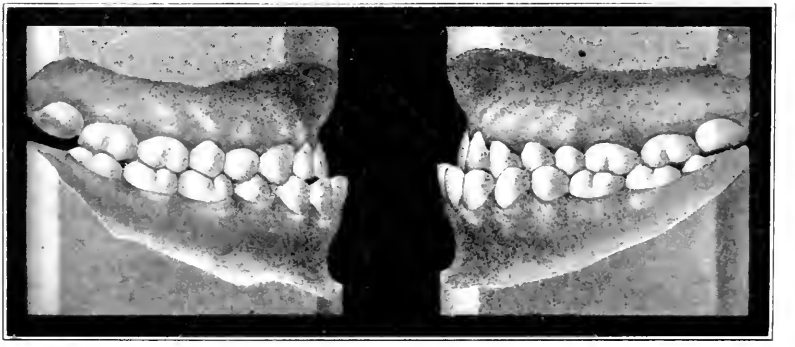


FIG. 83.—Malocclusion: Class III, Subdivision.

So much then for the classification or diagnosis of cases in which the first permanent molars are present. It is more than likely, however, that many cases will be seen before these molars are erupted or after they have been badly mutilated or even lost through the ravages of decay. For this reason it is well to note that the occlusion of

the second deciduous molars closely simulates that of the first permanent molars and consequently these teeth may be used as guides for classification. It has also been mentioned that the permanent cuspids are quite staple landmarks and are useful as guides to the occlusal conditions. At times the bicuspids may be all the individual has to offer from which to classify an abnormality. Hence the student can clearly see that an intimate knowledge of the normal relation of every tooth is absolutely necessary if an intelligent grasp of the abnormal is to be expected.

Etiology of Malocclusion.—One might write at great length upon the etiology of malocclusion without at all exhausting the subject. In this particular work it does not seem essential to discuss all the theories of all the theorists. The aim will be rather to disclose those facts, the knowledge of which will enable the hygienist to fulfill her avowed purpose of calling attention to, and so far as possible abating, those acts or causes which might bring about or aggravate malocclusion.

The factors involved as causative agents of malocclusion may be divided into the proved and the unproved. As examples of the unproved theories in relation to the causes of malocclusion, enlargement of the tonsils, nasal obstruction, mouth-breathing and adenoids may be mentioned. Whether these maladies do or do not contribute toward malocclusion, they are evidences of a reduced vitality, and as diseased conditions, should promptly be corrected.

We are told that mouth-breathing causes malocclusions, and that adenoids cause mouth-breathing. Conversely, however, certain good rhinologists hold that mouth-breathing induces adenoids, due to the fact that the inhaled air, normally passing through the nares produces a tonic effect upon the upper pharynx, whereas when taken through the mouth and thus more directly into the lungs, the area usually occupied by the adenoid vegetations misses this tonicity supplied by the air, and the hypertrophies are induced. An ordinary rhinitis, or head cold, especially during early infancy, by occluding the nasal air passages, forces the child to breathe through the mouth. If the rhinitis be long neglected, the mouth-breathing, which begins as a temporary necessity, may become a permanent habit. The theory at least sounds plausible enough. Consequently a hygienist who notices any conditions of this character, where her charges may be suffering with a head cold of long standing, should at once warn the parent or guardians of the possible ill-results. Far better would it be for the child to lose a few days' schooling while being kept in bed to cure a cold, than that the habit of mouth-breathing should become fixed.

Among the proved causes of malocclusion we may enumerate:

(*a*) The premature loss of deciduous teeth.

(*b*) Extraction of permanent teeth.

(*c*) Pernicious habits, and

(*d*) Lack of use.

There are other known causes which may be found in text-books, but those mentioned are of special interest to the hygienist.

(*a*) *The Premature Loss of Deciduous Teeth.*—The loss or extraction of a deciduous tooth, especially of the cuspids or any one of the buccal teeth, will almost inevitably produce a pernicious effect upon the permanent teeth. The space made by the loss of the temporary tooth almost invariably closes, in part or entirely, so that the opening needed for the oncoming teeth in that locality is reduced in proportion.

Why the Space Closes.—In the examination of a three-year-old arch, one wonders where the three large permanent molars will find space for eruption. This space, of course, must be provided by a growth of the maxilla and mandible distal to the deciduous teeth, distal therefore to the last deciduous molar. This growth is coincident with (if not actually caused by) the development and eruption of the permanent molars. The result is a forward or horizontal movement of the whole temporary arch. Let us study it in detail. To make room for the arriving first permanent molar, the temporary second molar must move forward. To accommodate this movement the first temporary molar must move forward, and so on around the arch, each tooth giving way as the tooth behind it advances. Let us suppose, however, that one of the temporary molars has been lost. A space is thus produced so that the first permanent molar may erupt without influencing the forward movement of any of the teeth anterior to the tooth extracted. Indeed, through lip pressure the space may even allow the anterior teeth to be forced backward. In this way, by closing of the space while the underlying bicuspid is yet deep in the bone, the bicuspid may be completely shut out of the arch, so that it either remains impacted, or else must erupt buccally or lingually of normal.

(*b*) *Extraction of Permanent Teeth.*—The loss of any permanent tooth breaks up the continuity of the arch and destroys the occlusion. It directly effects no less than five teeth. The two adjacent teeth losing the support of the extracted member, are often forced to drift or tip toward one another. This tipping and drifting is more likely to be extensive when the extraction occurs prior to the eruption of the second molars, as the eruption of these distal teeth induces a disarrangement of the teeth distal to such spaces. This tipping of the teeth interferes with the normal cusp interdigitation of these two teeth with the three antagonists of the opposite jaw. Thus, as has been said, the loss of one permanent tooth may directly spoil the occlusion of five others. Hence, of course, all permanent teeth which can be kept in a state of health, should be preserved when in normal position, and when out of position should be brought to normal occlusion, if possible.

(*c*) *Pernicious Habits.*—In regard to habits, perhaps the most common is sucking the thumb. This phrase, "sucking the thumb," is met throughout the entire literature, and is particularly supposed to

induce protrusion of the upper anterior teeth. But the thumb is not always in the mouth in such a way as to produce this effect, nor is it always the thumb which the child introduces into the mouth. Recently a casual glance into the mouth of a baby girl patient of four, disclosed what seemed to be a protrusion of the upper incisors. The mother was asked, "Does this child suck her thumb?" Like a flash the child replied, "No, I suck two fingers; want to see me?" and she proceeded to give a demonstration. She placed just two fingers of her right hand in her mouth, the finger-tips curled downward under her tongue. In this manner it would seem that the weight of her arm had held the mandible downward and backward, so that a marked example of Class II, Division 1, had been produced, although none of the temporary teeth had yet been shed. The apparent protrusion of the upper teeth was no real protrusion at all. As the child was not a sufferer from adenoids, had no nasal obstruction of any sort, had never been a mouth-breather, and was the picture of health, it is reasonable to attribute the deformity of the jaws in her case to this peculiar method of sucking the fingers. The thumb is also sometimes introduced into the mouth in the same manner, and not always with the ball of the thumb against the upper teeth.

Other baneful habits are sucking the lips or the tongue, or habitually resting the tongue between the incisors, not forgetting the abominable practice of nursemaids, and some mothers, of giving the baby a "pacifier" or "comforter."

These habits are particularly mentioned here because it seems probable that in the near future the sphere of the dental hygienist will be so broadened that she will enter the homes of many children long before they arrive at the school age, in which case an important part of her duty would be to look for, and warn mothers against, these habits.

(*d*) *Lack of Use.*—This brings us to a consideration of a lack of use. It is a commonly accepted physiological law that the use of any organ, or part of the body, contributes toward its development. Normal use results in normal development, where not hindered by other agencies. Abnormal or immoderate use may cause an overgrowth, as we see in the muscles of athletes; while disuse results in underdevelopment or even atrophy.

The Growth of the Jaws.—If we examine the normal child denture at the age of three or four, we observe twenty teeth symmetrically arranged about the arches and completely filling them. When we remember that these twenty deciduous teeth will be succeeded by twenty permanent teeth considerably larger in size, we recognize that if the latter are to erupt in normal occlusion, the bones of the arches must become enlarged, or in other words, there must be a growth increasing the circumference of the arches. Since the growth of the temporary teeth themselves is already complete, a growth of their bony supports must result in producing spaces between these teeth. We see this beautifully shown in Fig. 84, which illustrates the upper

and lower arches of a boy of four and a half years of age. We have but to glance at such a set of deciduous teeth to see how admirably Nature, when unhindered, will provide for all emergencies. We easily comprehend that, by growth, space is being provided against the advent of a set of larger teeth.

But what shall we think of such a set of teeth as is shown in Fig. 85? This child was five years of age, six months the senior of the

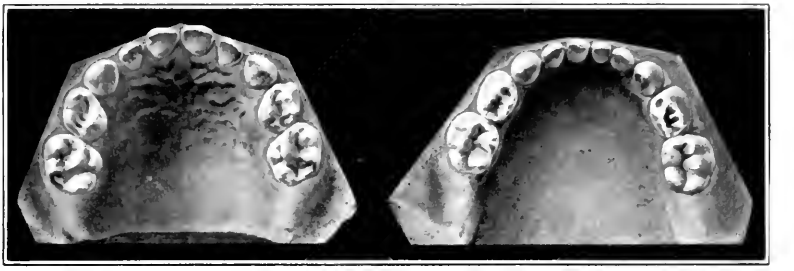


FIG. 84.—Normal growth of dental arches. Aged four and a half years.

other child, yet we find no spaces between the teeth and consequently no growth of the alveolar bone. We must wonder then, "Where will the permanent teeth erupt?" They certainly cannot appear in proper alignment with such a lack of space. These two models then illustrate well the contrast in appearance of a normally developing deciduous denture with one that is failing to take on proper growth.

It is but natural to believe that this development of the bones about the deciduous teeth is largely dependent upon the extent and nature of the use or disuse of the teeth.

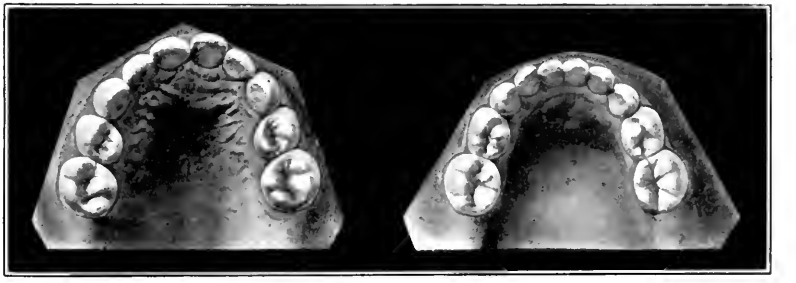


FIG. 85.—Undeveloped dental arches. Aged five years.

The normal use of the teeth would necessitate the thorough mastication of food; food thus masticated would be properly insalivated, and hence properly prepared for its reception by the stomach. With all the organs of digestion in a state of health, the result would be the thorough assimilation of the food, a correct metabolism, and hence a proper share of the nourishment would finally reach the jaw bones,

so that the thoroughness of the work done by the dental organs would bring its own repayment in the normal share of pabulum brought to the alveolar environments of the teeth. In this manner a normal physiological cycle would be established, and of course any disuse of the teeth would proportionately cause a disarrangement of this cycle.

While it is well to bear these facts in mind, yet there is another aspect of use and disuse of the dental organs to which attention must here be called. Entirely aside from any interference with the proper nourishing of the body and of the jaw bones, the use or disuse of the teeth directly affects the growth and development of the maxilla and mandible, through the muscular and mechanical forces of mastication. Indeed it is claimed that not only the bones of the jaws, but the entire cranium may be thus affected. To emphasize this fact, a liberal quotation is made from an article by Dr. Lawrence W. Baker, published in *Items of Interest*, February, 1911.

"Among the first voluntary coördinate muscular actions of a human being after coming into the world is that made with the muscles of mastication in taking food to sustain life. Long before the infant can hold up its head, or has gained control over those useful organs, the hands, the muscles of mastication are highly developed and are used with great vigor.

"During the act of nursing, the action of this set of muscles is so vigorous that it demands an increased blood supply, to the extent that the heart's action is greatly increased; the excessive flow of blood to these parts is indicated by a reddening of the whole head, and the fontanelles themselves are caused to pulsate so that the untrained observers comment on their movement.

"Later, with the advent of the dental equipment, this group of muscles is given more leverage, and its action becomes consequently more powerful; in fact, the force exerted on the bones of the head from the pull of these muscles during life is tremendous and amounts to many hundreds of thousands of tons of force. I have long been convinced that this great force on the skull, and the great flow of arterial blood to the head caused by this muscular activity, is a powerful influence in the development of the bones of the head and the important organs incased therein.

"It occurred to me that if the hypothesis regarding the influence of the dental equipment on the formation of the bones of the head were correct, interference with the laws of occlusion in the lower animals would show consequent effect in the formation of the bones of the skull; and if variation occurred it might throw some light on the most complex problem of the development of the human head.

"To test the theory the following experiment was performed: A litter of four rabbits was selected at the age of weaning. Two of the animals were operated on by grinding down all the teeth on the right side of the lower jaw and the superior right central incisor. As the teeth elongated, repeated grinding rendered them useless, so that

all the mastication was performed on the left side. The fourth rabbit was kept in the normal state for a standard of comparison.

"After seven months, the skeleton of one of the rabbits was procured and the skull was found to vary as shown in Fig. 86, which is a photograph of its upper aspect. It will be noted by the drawn lines that there is a deviation of the bones to the left. (Right and left in this description refers to the right and left side of the animal.) The suture between the parietal and frontal bones does not run strictly at right angles to the longitudinal axis of the skull; the right frontal bone projects farther forward than the left one. It will also be observed that the left zygomatic space is longer and more advanced than the right space. The most noticeable deviation is in the nasal bones, both bones being twisted to the left.

FIG. 86.—The upper aspect of the skull of a rabbit operated on. Observe the unequal development of each lateral half of the skull.

FIG. 87.—Lower aspect of Fig. 86.

"On the lower aspect of the skull, Fig. 87, it will be seen that the deviation extends throughout the entire skull. The most remarkable deviation is that the anterior root of the right zygomatic arch (the zygomatic process of the maxillary bone) is retreated while the body of the right maxillary bone itself with the teeth that it contained is greatly advanced.

"The results of this experiment seem remarkable to me.

"Who would have thought that by interfering with the laws of occlusion the skull would have decreased in weight, and that every

suture and every bone in the head would have varied as we have seen? This experiment strongly indicates how important is the masticatory equipment of man to the development of the head, and it also brings fresh illustrations of the importance of the sadly neglected temporary dentition which serves during the important developmental period of childhood."

The previous quotation gives in full the details of Dr. Baker's experiment, and his findings in one case. His examination of the second rabbit upon which he experimented disclosed exactly similar variations from the normal, whereas the control animal was practically symmetrical.[1] Until future experimenters prove these deductions to be erroneous, we may agree with Dr. Baker that the disuse of the teeth may result in extreme interference with the development, not alone of the jaws, but of contiguous parts of the cranium.

FIG. 88.—Caries of teeth causing voluntary disuse of the teeth.

Reasons for Lack of Use.—Disuse of the dental organs may be either involuntary or voluntary. It is involuntary when the habits of mastication are hasty, or where the food used is of such a character that heavy mastication is not necessary. What an injustice, then, is done to children who are fed upon gruels, sloppy food and other articles of diet which require little or no masticatory effort to reduce them to a consistency readily swallowed?

The voluntary disuse of the teeth is the direct result of caries which renders the chewing of food so difficult, or so painful, that the child elects either to swallow its food unchewed, or else to select food that needs no masticatory effort.

In Fig. 88, we see the right and left sides of the occluded models of a child four years of age. On the left side of the mouth caries has

[1] Dr. Baker has continued his experiments, and has had exactly similar results with animals other than rabbits. See his report thereon, Dental Items of Interest, July, 1916.

destroyed the little molars and cuspids almost to the gum line. We cannot look upon this picture without thinking of the rabbits, whose teeth Dr. Baker filed or ground away to prevent mastication on one side. When we recall the results of the experiment with the rabbits, we begin to appreciate the seriousness of such conditions in a human young one, during the most stressful periods of development. The word stressful is used because, whereas an adult needs only to restore the tissues of his body which are lost by use, a child must likewise do this and at the same time obtain and assimilate sufficient food with which to increase his weight and stature. How can he do this handicapped with a masticating apparatus so destroyed? In the experiment with the rabbit, Dr. Baker left the little animal with one side of his masticating apparatus perfect, so that perhaps he might properly masticate sufficient food for the proper nourishment of his body. It is this fact that made Dr. Baker's results so significant. There is every reason to believe that the rabbits operated upon ate just as much food as the control animal, so that the divergencies from normal found in the skulls were not attributable to lack of nourishment, but to lack of use of one side of the jaws.

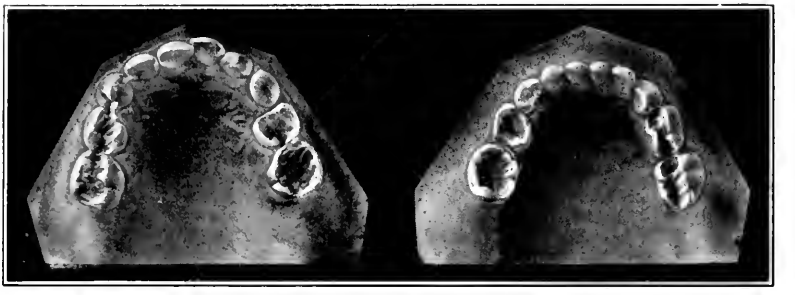


Fig. 89.—Same case as Fig. 88, occlusal view.

The child whose models are shown fared not so well as Dr. Baker's rabbits, because on both sides occlusion was extensively interfered with. The cavities in the teeth are so large that a considerable portion of their occlusal areas has been lost, and the approximal contacts likewise having been destroyed, the protection of the interproximal septa has disappeared, so that food readily packs upon these easily injured and sensitive tissues, with the result that mastication becomes painful, and the child voluntarily declines to use his teeth.

Fig. 89 shows the occlusal view of these two jaws, and the extent to which caries has destroyed the occlusal contactual area is disclosed. Comparing these models with those shown in Fig. 84 we note the lack of development.

At this point it may be well to consider again the models shown in Fig. 85. These likewise show lack of development of the arches, yet the teeth themselves are not affected by caries, so the child could

have used them perfectly; therefore it is not to be claimed that disuse is the sole cause of lack of development. It may be the chief cause in some instances and only one of several factors in others. In the case of the child whose models are shown in Fig. 85, the physical history is not known. It will suffice for present purposes to consider two possible hypotheses. While this child cannot have suffered from

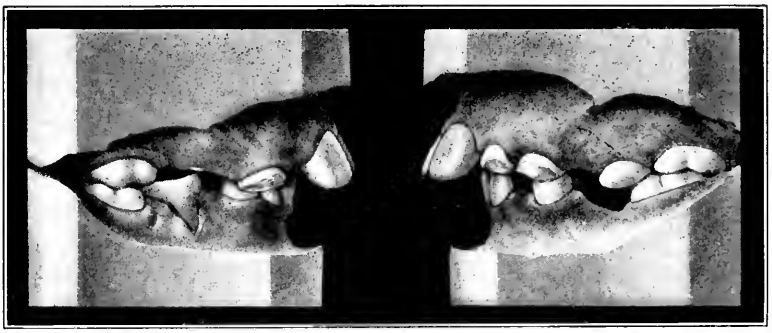


FIG. 90.—Malocclusion due to lack of use.

voluntary disuse of the dental organs, since the teeth are all sound there may have been involuntary disuse due to the soft nature of his food. Again, considering the perfectness of the teeth, this may not be a case of lack of development at all. There is no definite age at which a particular development of the jaws must occur. We cannot say certainly that the first permanent molars will erupt at a stated

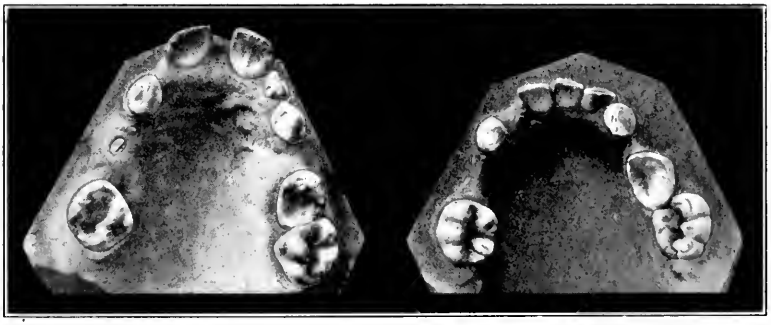


FIG. 91.—Same case as Fig. 90, occlusal view.

age, the incisors at another, the cuspids at another. The writer has seen a complete denture of thirty-two teeth at the age of fourteen, and in another case, the upper cuspids arriving as late as the nineteenth year, in which case all the previously erupted teeth had likewise appeared long after what is supposed to be the normal time of eruption. Looking at a child denture prior to the eruption of the first

permanent molars, if we note growth spaces, as seen in Fig. 84, we may say that normal development is present, but in the absence of such growth spaces, as in Fig. 85, we cannot positively decide. It may be a case of lack of development (as a mere illustration of which the models are used), or it may be a case of slow or tardy development.

As examples of a period slightly later than that shown in Figs. 88 and 89, Figs. 90 and 91 are introduced. This child's mouth was first examined prior to the appearance of the permanent molars. Not a tooth in the two arches was free from caries. The upper incisors were barely showing above the gum line, and all four were abscessed, for which reason they were extracted, as were three or four others. Complete lack of occlusion existed. The child was undersized, anemic and of a generally degenerate appearance. Her father was a physician, however, and after removal of the abscessed teeth he was advised to feed the child on food that would yield as much nourishment as possible. It was impossible to obtain models of her mouth; it would have been cruel to try. When next she was seen, two years later, the models here illustrated were made. Even with the eruption of the first molars, the masticating possibilities have not been greatly improved, as they decayed almost as fast as they appeared, so it was said. However that may be, we have here a marked case of prolonged lack of use and malnutrition and cannot be surprised at the resultant malocclusion. On one side we note that the lower molar is in distal occlusion. On the other side the occlusion of the molars is apparently normal, but there is little reason to doubt that the lower molar has drifted forward because of the premature loss of the two temporary teeth. In any event it is a marked example of malocclusion due to lack of use following the ravages of caries in the temporary set, so that from this case alone we may gain some cognizance of the possible evils of dental disease which might have been prevented to a great degree by proper attention to mouth hygiene.

CHAPTER V.

INFLAMMATION.

By Le ROY M. S. MINER, M.D., D.M.D.

Inflammation may well be called the cornerstone of Pathology, for an accurate conception of the principles involved in the phenomena of inflammation is necessary in order to have a foundation upon which to build a knowledge of general pathology.

Inflammation in its various forms is so exceedingly common that without a knowledge of the changes that take place one cannot hope to understand the manifestations which occur in diseased conditions.

Definition.—Inflammation may be described, in a word, as a response or reaction to an irritation or injury. Its *purpose* is twofold:

1. To counteract or neutralize the agent causing the injury.
2. To repair the injury produced.

Thus it is seen that inflammation is intended to be a building up process; a beneficial effort of Nature to repair damage. Unfortunately it not infrequently happens that under unfavorable conditions it becomes distinctly destructive instead of reparative.

Classification.—The many types of inflammation have been classified in various ways. The terms most frequently used, however, are (1) acute and (2) chronic.

It may also be classified according to the *location*. *Catarrhal inflammation* affects the epithelial structures, especially the mucous membranes; inflammation is said to be *Interstitial*, when the connective or supporting tissues are involved; or *Parenchymatous*, when the functionating cells of an organ are attacked.

Inflammation has also been described as *Ulcerative*, when there is loss of tissue by necrosis or gangrene; *Exudative*, when the process is characterized by unusual exudates as in pleuritic effusion; *Suppurative*, when the inflammation ends in suppuration or the formation of pus.

While these classifications help to describe the location or the type of inflammation, and while the clinical aspects may vary somewhat, it must be firmly borne in mind that the phenomena of the reactions which take place are essentially the same in all forms. The location of the injury will determine to a considerable extent the effect, but the reaction is fundamentally the same.

Inasmuch as the circulation of both blood and lymph plays a very important role in the phenomena of inflammation, it is necessary to have some knowledge of the normal circulation and also some

idea of the simpler tissues which may be affected before studying the process itself.

The Normal Circulation.—The circulation of blood differs in each of the three types of vessels.

In the *arteries*, which carry the fresh red blood, the flow is intermittent, the red blood corpuscles flow in the center of the vessel (axial core), while between them and the vessel wall is a colorless zone called the plasma zone. The white blood corpuscles travel in this zone and travel much more slowly than the red corpuscles.

In the *capillaries*, or the intermediate vessels, the blood flow is slow and continuous. There is no plasma zone.

The flow in the *veins* is continuous and slower than in the arteries. The plasma zone is present, but less sharply defined than in the arteries.

The Constituents of the Normal Blood.—The chief constituents of the normal blood are eight in number, as follows:

I. Red blood corpuscles, erythrocytes.
II. Blood platelets.
III. Polymorphonuclear leukocytes (leukocytes with many nuclei).
IV. Endothelial leukocytes.
V. Lymphocytes.
VI. Eosinophiles.
VII. Mast cells.
VIII. Blood plasma.

Groups III to VII are various types of white blood cells.

The *red blood corpuscles* are bell- or cup-shaped masses of cytoplasm containing no nucleus. One cubic millimeter of blood under normal conditions contains 4,500,000 to 5,000,000 red corpuscles and at birth about 6,000,000. These corpuscles are not permanent cells, but are short-lived. Their function is the carrying of oxygen, which forms a loose combination with hemoglobin, which is the most important constituent found in the protoplasm of these cells. The red blood corpuscles are derived from the erythroblasts of the bone-marrow.

The *blood platelets* are round or oval disks about one-half the size of the red blood corpuscles. One cubic millimeter contains 250,000 to 500,000 platelets.

The *white corpuscles* grouped together are present in much smaller numbers than the red blood corpuscles, there being only 8000 per cubic millimeter on the average. There are about 600 red to 1 white corpuscle.

The *polymorphonuclear leukocytes* are the most frequently found white corpuscles and form 70 to 72 per cent. of the total number. They are larger than the red blood corpuscles. Under the microscope the nucleus of this cell attracts attention. The nucleus is irregular and has rounded lobules. The cell membrane is sharply defined. These cells are formed in the bone-marrow also.

Endothelial leukocytes or *mononuclear leukocytes* are larger even than the polymorphonuclear cells, being two or three times as large as the red blood corpuscles. In number they make up only 2 to 4 per cent. of all the white cells. They are derived from the endothelial cells lining the bloodvessels.

The *lymphocytes* are found most frequently next to the polynuclear cells. They form 22 to 25 per cent. of all the white corpuscles. They are about the size of the red corpuscles. The appearance is characteristic. The cells are round and they take the stain well, especially the periphery. Lymphocytes are produced in lymphoid tissue and especially in the lymph nodes.

Eosinophiles make up 2 to 4 per cent. of the total leukocytes. The nucleus is frequently shaped like a horseshoe, and the cell itself may be larger than the polynuclear leukocytes. It derives its name from the intense staining with eosin. They are derived from bone-marrow.

The *mast cells* make up but five-tenths of 1 per cent. They are also derived from bone-marrow.

Blood plasma is the fluid part of the blood and contains fibrin, which plays an active part in the phenomena of coagulation. With the fibrin removed the plasma is called serum.

In addition to this brief study of the blood and its circulation it may be well to mention some of the basic histological structures which are concerned in the study of the inflammatory process. They are as follows:

I. Connective tissue (fibroblasts).
II. Endothelial cells.
III. Nerves.
IV. Lymph vessels and spaces.
V. Bloodvessels.

Connective Tissue.—The function of this tissue, as the name suggests, is to bind or support other tissue. The cell of which it is formed is called the fibroblast. These cells, as a rule, are flat, elongated cells with oval nuclei. The fibroblast frequently plays an important part in inflammatory processes.

Endothelial Cells.—These cells line the blood and lymph vessels. In form they are flattened and have an oval nucleus.

The inflammatory process may be divided into three parts:

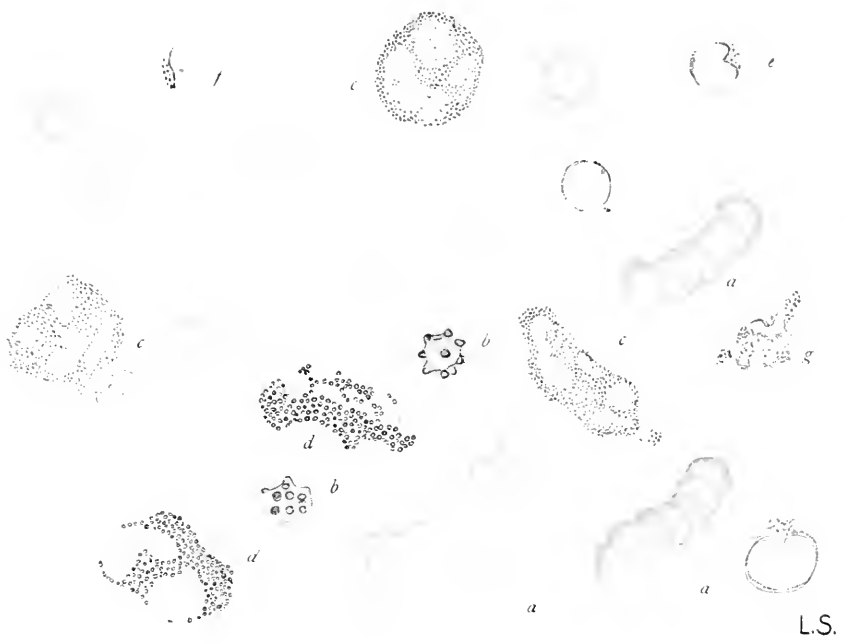
I. The injurious agent or the cause.
II. The injury done to the tissues.
III. The resulting reaction to the injurious agent and to the injury.

The Injurious Agent or Cause.—Some writers have classified the causes of inflammation under two headings:

1. The predisposing cause.
2. The exciting cause.

As a *predisposing cause* of inflammation age may be mentioned. In growing children, the nutritional and developmental changes predispose to inflammation of the mucous membranes. The frequency

PLATE IV



The Elements of Normal Blood. (Simon.)

a, red cells in rouleaux; *b*, crenated red cells; *c*, finely granular (neutrophilic) leukocytes; *d*, coarsely granular (eosinophilic) leukocytes; *e*, small, and *f*, large mononuclear leukocytes; *g*, plaques.

of stomatitis in children is an example. In old age the lowering of the resistance predisposes to the inflammations of bacterial origin. Bronchitis is an example. Fatigue and worry are said to be predisposing causes. Any condition that lowers the natural resistance may be regarded as a predisposing cause.

The *exciting cause*, or the active injurious agents may be divided into three groups:

I. Mechanical: cuts, blows, foreign bodies.

II. Physical: heat, cold, sunlight (sunburn), electricity, *x*-ray, radium.

III. Chemical:

(*a*) Inorganic compounds: acids, alkalies, poisons.

(*b*) Organic: microörganisms, bacteria and their toxins.

This last group, especially the bacteria, form the chief cause of inflammation. In fact, so commonly is bacterial invasion the cause that it has been incorrectly assumed that inflammation was dependent upon bacteria or their products. As a matter of fact the lesions produced by the injurious agents other than bacteria are identical to those of bacterial origin.

It is not necessary to go into great detail regarding the bacteriology of inflammation, but some of the more common bacteria may be briefly described. The three most common organisms are the Staphylococcus pyogenes aureus, Streptococcus pyogenes and the pneumococcus.

The staphylococcus is found on the skin, or in the mouth, and is very common. It may possess little or no virulence, or it may become extremely pathogenic when abnormal conditions exist. It is the most frequent organism found in pus. It is a small, round cell and tends to form in groups or clusters. When grown artificially it produces a distinctly yellowish color in the medium.

The streptococcus is a more dangerous organism, but it is not so common as the staphylococcus. It is not infrequently found in the mouth and nose. It is often found in suppurative conditions with the staphylococcus. It is a spherical organism which has the characteristic of growing in chains.

The pneumococcus is found frequently in inflammatory conditions. It is said to be a normal inhabitant of the mouth. Morphologically these organisms appear like elongated cocci and tend to grow in pairs or short chains. Under some conditions a well-defined capsule is seen. This organism has been found very frequently in the inflammatory conditions of the alveolar process, commonly known as pyorrhea alveolaris. The Bacillus pyocyaneus, typhoid bacillus, colon bacillus and tubercle bacillus are other notable examples of pathogenic bacteria which produce their more or less characteristic inflammations.

The action of an injurious agent may be severe or slight, brief or prolonged. The effect varies accordingly. Some agents produce a lesion very quickly, others only after acting over a long period of

time. The action may be local or general: local, as in the case of a blow; general, as in the case of diphtheria toxin.

The Injury.—*Definitions.*—*Injury* is the term applied to the changes produced in tissues and organs by harmful agents.

Lesion is the term applied to any structural change in tissues and organs, no matter how produced.

Necrosis means death and may be used to indicate death of any tissue, or of a single cell.

It is possible for injury to have been done without being able to demonstrate it. In tetanus and rabies it may be impossible to demonstrate any morphological change, even though the reaction is most violent. Thus it is seen that inflammation is not necessarily a local reaction.

The Reaction.—The *reaction to an injurious agent* is the most interesting. This reaction naturally varies very considerably, and this depends on the amount and nature of the injurious agent and on the severity of the injury. It may be evidenced in three ways:

I. By chemical changes, as alteration in secretion or excretion.

II. By morphological changes, as the presence of serum, fibrin and proliferated cells.

III. Physiologically, by alteration in functional activity.

As already stated, the *object of the reaction* is to get (*a*) rid of the injurious agent, if it is still present; (*b*) to neutralize its action; and (*c*) to repair the injury which has taken place.

The chemical and physiological changes are usually less prominent than the morphological changes. The changes in the blood following poisoning by illuminating gas is a good example of the chemical change. The convulsions produced in poisoning by strychnine illustrate the physiological changes.

Inasmuch as the morphological changes are most frequently seen and have been the most thoroughly studied, this phase of the subject can be studied to advantage.

The *morphological changes* (which are partly chemical) which take place in tissues following an injury are as follows:

I. Circulatory disturbances.

II. Inflammatory exudation.

The Circulatory Disturbances.—These occur in the following order:

1. A momentary spasm in the bloodvessels, when the irritant first acts.

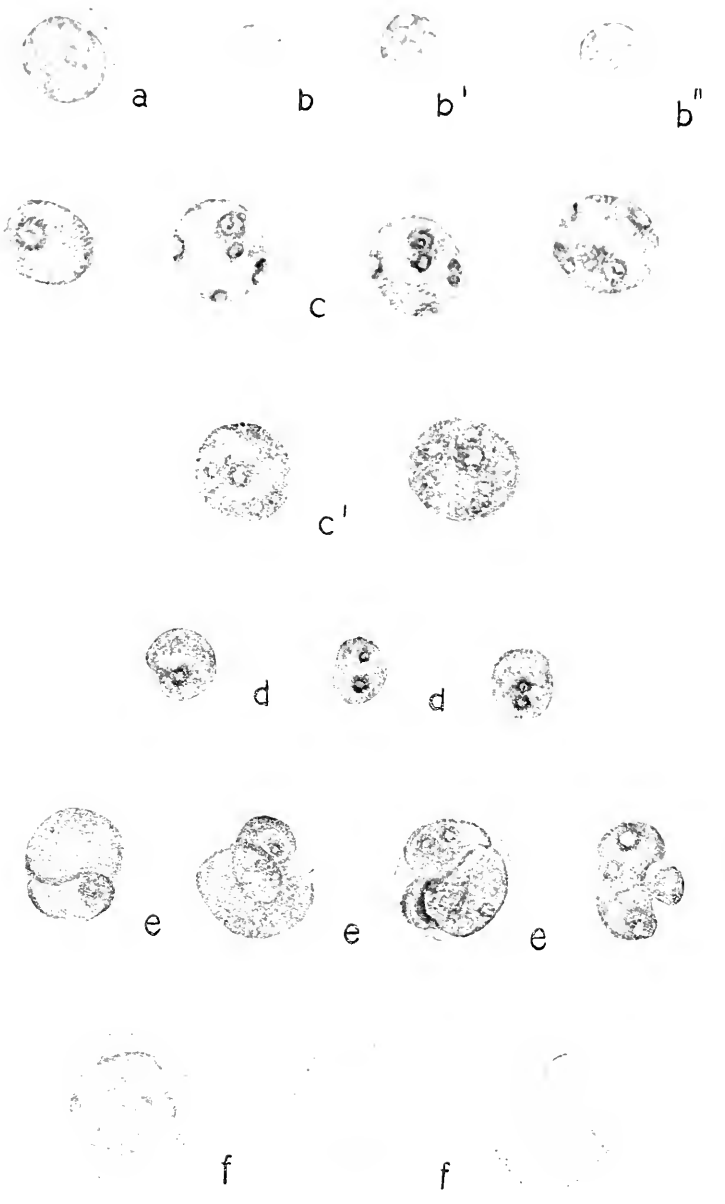
2. Dilatation of the vessels with a more rapid flow.

3. The vessels still further dilate and become engorged, but the flow decreases, and may even stop in some of the capillaries and veins. The leukocytes become attached to the walls of the veins.

4. The transmigration of the leukocytes.

These cells, especially the polynuclear form, have been called the soldiers of the blood, for they rush to the seat of injury and slowly but surely pass through the vessel wall into the tissues (ameboid move-

PLATE V



a, macrolymphoblast; *b*, microlymphocyte; *b'*, older form; *b''*, monocytoid form; *c*, macrolymphoidocytes; *c'*, monocytoid forms; *d*, microlymphoidocytes; *e*, Rieder forms of macrolymphoidocytes; *f*, large monocytes. (Simon.)

ment) and invade the masses of bacteria, or surround the irritant if non-bacterial and attempt to destroy them. These cells themselves are killed in great numbers by the actions of the product of the bacteria, namely, the toxins.

The endothelial leukocytes appear later in the inflammatory process, when the polynuclear forms are diminishing in number, acting as a sort of reserve guard. They accumulate to counteract the toxins of the bacteria and to attend to foreign bodies, carbon and free fat. These cells destroy certain forms of bacteria by enveloping them in the cell structure. *Phagocytosis* is the term used.

The lymphocytes are seen most abundantly after the inflammation has existed for some time, and are quite characteristic in what we know as chronic inflammation.

Symptoms of Inflammation.—While these changes are taking place in the tissues, certain symptoms of the inflammatory process have appeared, of which the patient is very conscious. These symptoms are four, to which a fifth is sometimes added. They have been called the *cardinal signs of inflammation* and are classic. These are: Rubor; calor; tumor; dolor; the fifth, functio læsa; translated these are: redness; heat; swelling; pain, and impaired function.

1. The *redness* is due to the increased flow of blood. *Hyperemia* is the term that is sometimes used to distinguish the early stage of inflammation. As the flow begins to decrease, the color begins to become bluish in appearance.

2. The local *heat* at the site of the inflammation never exceeds the temperature of the internal organs, although it may be above the normal temperature of the part. No heat is produced in the affected area. The increased temperature is due to the increased rapidity of circulation and to the increased volume of blood.

3. The *swelling* is produced by the exudation from the blood-vessels.

4. The *pain* is due to pressure on the nerves by the exudates. It is often possible to count the heart beat by the exacerbations of pain. The pain is most severe in dense structures, especially when the inflammation is confined in bony walls, as in the pulp of a tooth. This pain is sometimes referred to a point distant from the seat of trouble, as for example, earache in case of pulpitis.

5. The *disturbance of function* is especially seen in the effect on secretions, which many times are prevented or suppressed. Also movement may be limited, as seen in stiffness in a joint that is inflamed.

The Inflammatory Exudate.—Associated with or following closely after the transmigration of the white cells, there is an *exudation of lymph* from the lymph vessels, the purpose of which is to neutralize or to reduce the chemical activity of toxins given off by bacteria or other products present in the tissues. The exudation of lymph is seen, as an illustration, in a mosquito bite. We have here a chemical poison, and we get all the changes incidental to inflammation. That

is, the change in the circulation; the increase in rapidity, then the slowing down of the blood stream, the transmigration of the leukocytes, and finally the throwing out of lymph. This is a small inflammation, but it has all the phenomena of a more extensive one.

If at this point, the most important purpose of the inflammatory reaction has been accomplished, namely, to counteract or neutralize the agent causing the injury, the inflammation subsides, the early products of the inflammatory process are absorbed and the tissues soon return to a normal condition.

Unfortunately, however, especially where bacteria are concerned, Nature is not always successful, and other phenomena appear. Further exudates are thrown out; the exudation becomes more complicated, and other substances besides the lymph are thrown out. These *exudates vary* under different conditions.

Types of Exudation.—I. *Serous exudation* is watery in consistency, and is quite similar to lymph; in fact, it resembles it very closely, and some writers simply regard the serous type as an unusually free exudation of lymph. In this form the lymph spaces are particularly involved and the swelling is known clinically as *edema*. This is seen sometimes in a sprain. Pressure with the thumb or finger over the swollen area will usually leave an indentation, where the serum has been forced out of the tissues by the pressure. This identation gradually disappears as the pressure is removed and as the serum flows in again.

Another example of this serous type of exudate is a blister from an ordinary burn, or from irritation, or friction.

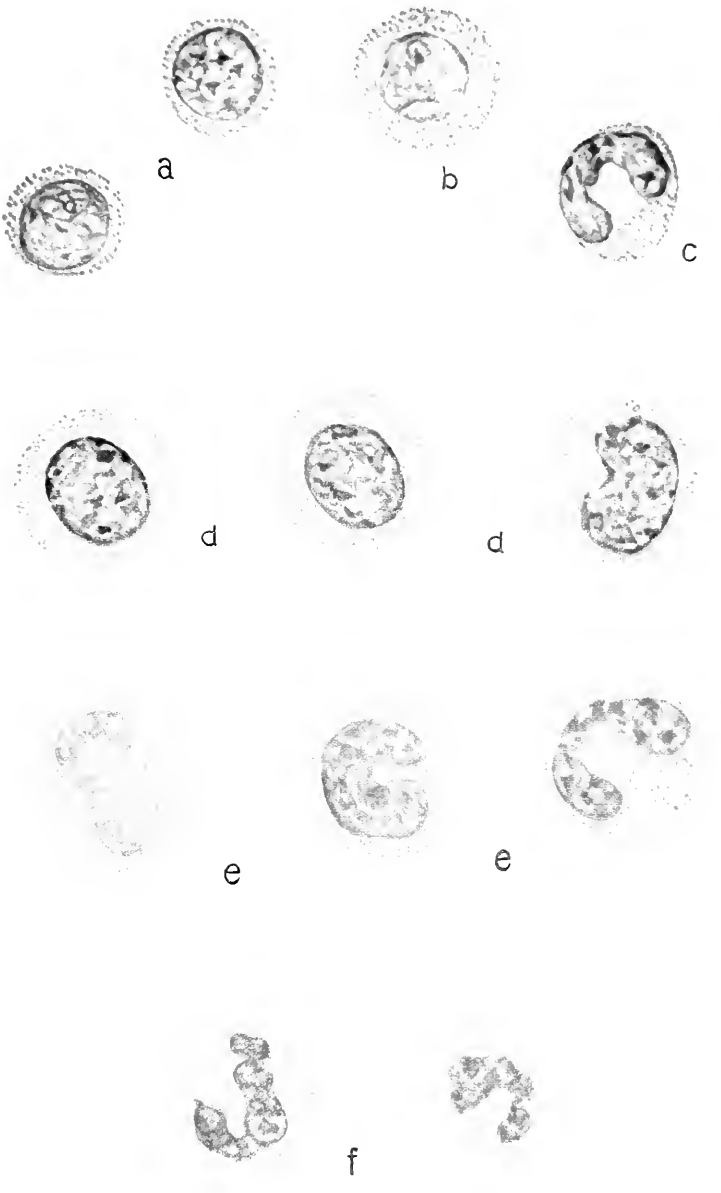
II. *Fibrinous exudation* consists of leukocytes and the formation of fibrin and occurs most characteristically in the form of a membrane. A good illustration of this is the membrane formed in diphtheria.

These membraneous exudates vary in their characteristics. Some are firmly adherent to the underlying tissues, while others may be readily peeled off, leaving sometimes a bleeding and sometimes a smooth surface.

III. *Suppurative exudation* is the most frequent and most important form, and is characterized by the formation of *pus*. This is the most common ending of acute inflammation, especially when bacteria are acting as the injurious agent.

In the discussion of inflammation caused by bacteria, it was shown that leukocytes were clustered together and the lymph had been thrown out. What is the next phenomenon to appear? It is briefly that the large number of leukocytes which gather in the tissue form an impairment of the nutrition of the tissue in which they are located; and we are so made up economically, so far as our tissues are concerned, that the nutriment supplied to the tissue is not sufficient to nourish the tissue itself and also these leukocytes, with the result that the tissue cells themselves lose their vitality; and then, also, the leukocytes in giving battle to the bacteria are destroyed in large numbers, either

PLATE VI



a, typical leukoblast; *b*, old form; *c*, monocytoid form; *d*, neutrophilic myelocytes; *e*, neutrophilic metamyelocytes; *f*, polymorphonuclear neutrophiles. (Simon.)

by the bacteria or their toxins. This lack of nutrition, this dying of the tissue cells in which the inflammation is located, and the death of the leukocytes themselves, cause a dissolution of the tissue, and as a consequence there is a cavity filled with dead leukocytes, dead tissue cells, lymph and dead and living bacteria, which forms a creamy fluid called pus. Clinically this is known as an *abscess*.

The formation of an abscess marks the end of the inflammation, so far as the tissues themselves are concerned; that is, the inflammatory process has been limited and localized.

The leukocytes which transmigrate into the tissues entirely surround the seat of injury and *form a protecting wall* against further invasion.

If it were not for this action of the leukocytes in forming this wall between the general circulation and the injurious agent in the form of bacteria, each time we received an injury infectious in its nature, that is, of bacterial origin, we would either have a general blood poisoning because injurious products would be taken up by the circulation, or the inflammation would extend indefinitely out into the tissues until our bodies were wholly consumed by the inflammation. Therefore this formation of an abscess, while disagreeable, painful and uncomfortable, in itself is an excellent thing, because it prevents the disturbance from becoming a general one of very serious consequences.

Occasionally the leukocytes are unable to control the local action, or perhaps the infection began in the circulation, and in that case general blood poisoning or *septicemia* results. This is a very serious condition. But, fortunately, the leukocytes generally form an actual resisting force, or limiting membrane, through which the bacteria are unable to pass and inside of which is this pus cavity.

The next question that naturally arises is, what becomes of the pus and this wall of leukocytes? The tendency of all abscesses is to evacuate themselves; that is, to throw off their contents, and get rid of the secretion that exists. The method of doing this is as follows: The fluid elements of the abscess cavity, or the pus, increases in amount, and the increase in quantity increases the pressure around the tissues, and as this fluid element continues to increase, the pressure becomes greater and greater, and as the pressure becomes greater the tissue before it gradually yields, and the pus finds its way in what has been classically called the *path of least resistance*. This act of Nature in endeavoring to throw off the pus has been called the burrowing of pus. It tries hard to get through to the surface of the body, or to a cavity, and burrows its way through the tissues in the path of least resistance. When the pus has finally approximated the surface, we have what is known as *pointing*. This term is well known. Years ago it was customary to poultice any inflammatory condition to bring, as they said, the trouble to the surface, and this poulticing was intended to hasten the action of the pus burrowing, to hasten the pointing of the abscess so that the contents could be evacuated.

If an abscess is not surgically opened and the pus discharged, the tissues will spontaneously rupture and the pus will escape, either on the surface of the body somewhere, or else into one of the cavities of the body, as has been suggested. For instance, if an abscess on the lower jaw results from an inflamed tooth, the path of least resistance may be downward and a large swelling occurs under the jaw. As the pus comes closer and closer to the surface it either is opened and evacuated surgically, or else it may point and discharge underneath the chin. If there is an abscess, for instance, in the appendix, and it is allowed to go uncared for until it ruptures, it ruptures into the abdominal cavity and peritonitis results. The pus, in other words, tries to escape from the tissue and come out freely, and thus relieve the pressure on the tissues in which the abscess has formed.

The channel through which the pus passes is called a *sinus*, and the opening on the surface is called a *fistula*. These two terms are very common, especially in inflammatory conditions connected with the mouth and teeth. We speak of a sinus, for instance, when a chronic abscess discharges into the mouth over a tooth on the gum. The canal or channel through which the pus escapes to the surface is the sinus, and the opening on the gum out of which the pus comes is the fistula.

If the abscess is a very superficial one, it is merely a simple abscess of the skin. When the pus comes through the surface the layers of the skin may be destroyed, leaving more or less of an open wound of a very superficial nature. This condition is known as an *ulcer*.

Chronic Inflammation.—Before discussing repair or what takes place after the pus is evacuated, chronic inflammation may be briefly described. *Chronic inflammation* is the *result* of a *continued irritation*. It may follow acute inflammation, or it may start as inflammation of a chronic form. Chronic inflammation is a very different process from the acute form, and some writers have gone so far as to say that chronic inflammation is not a true inflammation at all. The essential feature of chronic inflammation is the formation of new connective tissue, a proliferation of the fibroblast, or connective-tissue cell. The term fibrosis has sometimes been applied to this form of tissue change, because it describes the condition better than the term chronic inflammation.

In this chronic inflammatory process, hyperemia, or change in the bloodvessels, that is, the bringing of additional blood to the part, edema, the throwing out of the lymph and suppuration, the formation of pus, are absent. Instead there is this proliferation, as it is called, of the connective-tissue cell, and the throwing out of some of the white cells of the blood, particularly the lymphocytes. The *chief characteristics*, then, are the formation of connective tissue, the fibroblastic proliferation and the lymphocytic infiltration or throwing out of these lymphocytes. No pus is found nor other symptoms of the inflammatory changes.

Repair.—Repair is the general term used to describe the processes taking place after injury and exudation caused by harmful agents. The repair of tissue or the repair of the injury is a very complicated subject but it includes three divisions which will be briefly described:

First, repair includes removal of foreign bodies of all sorts; and by foreign bodies is meant dead cells of all kinds: (1) Tissue cells that have died as the result of the process, (2) leukocytes of the polynuclear form, (3) endothelial leukocytes, (4) bacteria dead and alive.

The absorption and removal of foreign bodies such as sutures should also be included. There may be an operation and stitches are taken deep in the body. These stitches are allowed to stay there, and they are removed as foreign bodies, and this is part of the function of repair. In addition, secretions from bacteriological products, the toxins, and in some cases the lime salts which are formed as the result of the various conditions are included; in fact, the removal of anything that is foreign, or is not of service in the tissue is one of the functions of repair.

Second, the organization of fibrin.

Third, the regeneration of cells to restore the part which has been destroyed.

I. How does the removal of the foreign bodies take place? In a word, the leukocytes, or white cells, change somewhat their function, and they become active in carrying off the foreign bodies.

These dead tissue cells are destroyed and removed in part, a little at a time. The bacteria may be actually digested by the leukocytes after being taken up by these cells. Very frequently under the microscope these endothelial cells may be seen with several bacteria in their protoplasm. The endothelial leukocyte is especially active in this part of the process. The phenomenon is called phagocytosis.

II. The fibrinous exudate is taken care of by the connective-tissue cells, the fibroblasts, which form and grow into the fibrin and gradually replace it.

III. The regeneration of cells is the growth of new cells, and is brought about by what we know as cellular division, or mitosis. Under stimulation, the cells in the vicinity of the wound will gradually begin to multiply and fill in the vacancy that is caused by the destruction of the tissue, and gradually this cavity or the injury due to loss of tissue is replaced by new cells, which have divided and redivided and divided again.

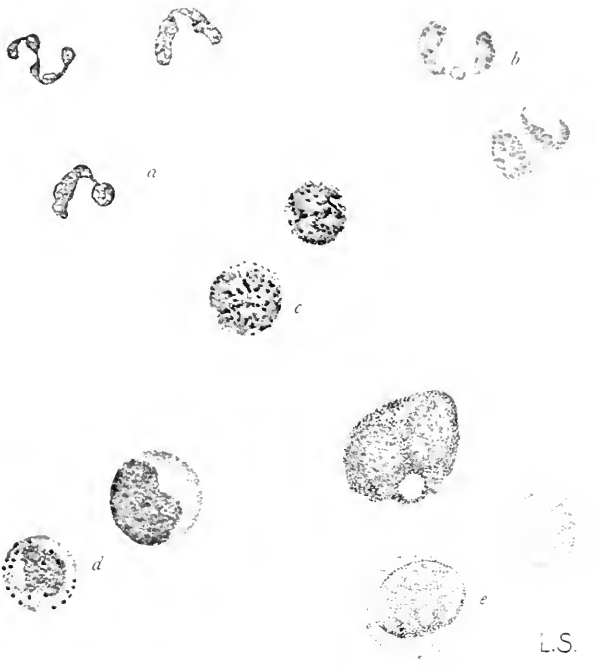
Clinically speaking, repair or the healing of wounds takes place in two ways: (1) By primary healing, as we know it, called *healing by first intention;* and (2) by secondary healing, or *healing by second intention,* or healing by granulation tissue.

Healing by First Intention.—To illustrate the healing by first intention, let us assume we have an incised wound. After the bleeding is stopped the wound, which is the result of a cut remains filled with blood, and this blood coagulates and forms a sort of plug in the wound. This plug or coagulated blood retracts and tends to hold

the edges of the wound together, and over the surface a crust is formed, which is nothing more than dried secretion, dried lymph plus a few cells, and this is commonly spoken of as *scab*. The healing process begins at once. Of course, the various stages of inflammation, the changes in circulation, and throwing out of the leukocytes must occur, but all of the cardinal symptoms of a true inflammation may not be present. In addition to the throwing out of the leukocytes, the connective-tissue cells become active; and this blood-clot, which has been mentioned above, acts as a sort of scaffolding, upon which the connective tissue builds, sending out little prolongations of tissue. This connective tissue gradually replaces the blood-clot and the edges of the wound are held firmly together. Then if the wound is on the surface, the epithelial coverings will send out prolongations and heal it over with no evidence of scar. If the edges of the wound after a cut are held firmly together, for instance, with plaster or a bandage, very little connective tissue is formed. It takes very little new tissue to repair the wound; but if it is a gaping wound, more material is needed to repair it; and where a portion of the surface of the skin is lost and it becomes impossible for the epithelial cells to span the breach, the connective tissue fills it in, and the result is known as a *cicatrix*. The tissue which forms is called cicatricial tissue, or *scar tissue*. This has a very great tendency to contract. As these new cells become older they contract somewhat, and the contraction of scar tissue is well known. The scar tissue that results where the epithelium is not completely restored, for instance, on the hand, is not original skin tissue, but it is made up of connective tissue.

Healing by Second Intention.—It has been shown that healing by first intention has nothing to do with infection; that is, bacteria have been absent in the changes that have taken place. In repair, by second intention, however, the suppurative process, and all the phenomena of inflammation with the formation of pus and the evacuation or throwing out of pus cells, and the products of exudation must occur before the actual healing. When this takes place, the cavity which results from the pus is filled in gradually by granulation tissue and connective tissue in much the same way as in healing by first intention; but there is much more tissue to be restored, and the healing process may be slow, particularly if the cavity is large. It is often possible, after the pus has spent itself and the acute symptoms have subsided, to bring the edges of a wound together and have it heal by first intention, but that is not customary. If instead, in this type of wound the opening is packed with gauze, and allowed to fill in, as we say, from the bottom, the granulation tissue fills up gradually, and each day less gauze is used in the packing until the cavity is filled in solidly with this connective tissue. This healing by granulation becomes very important under some conditions, because the contraction is sometimes excessive. If there is a severe inflammation or a bad abscess of the cheek, for instance, or the cheek muscle and the wound has to be repaired by second intention, or by granulation healing,

PLATE VII



Granulocytes. (Simon.)

a, polynuclear neutrophilic leukocytes; *b*, polynuclear eosinophilic leukocytes; *c*, mast cells; *d*, eosinophilic myelocytes; *e*, neutrophilic myelocytes (the smaller myelocytes represent the micro-, the larger ones the macro-type); *f*, the nucleus here has just undergone division; the clear space is a vacuole.

after a while this contraction of the cicatricial tissue may be so great that the person is unable to extend the lower jaw or open the mouth, and thus a very serious condition may be developed. Fortunately this is not common.

Repair then in general is the effort of Nature to restore the tissues to a normal condition after an inflammation; and when the repair is complete, especially if it is by first intention, the parts have been restored to function and the cells resume their normal relations.

INFLAMMATION AND REPAIR OF BONE.

Introduction.—We ordinarily regard the bones as more or less stationary in the structure during life, but they are in fact the site of constant cellular activity and are subject to continual alterations in size, shape, strength, density and composition. All bones possess ridges or processes that have a definite anatomical or physiological reason for existence but which begin to disappear at once when their function is fulfilled. The most conspicuous example of this is the alveolar process of the jaw which is especially designed to support the teeth. These alveolar processes maintain their integrity under normal conditions when the teeth are present, but are absorbed in a comparatively short time when the teeth are lost. The cells that serve to maintain the integrity of bone or to remove unnecessary portions, as the case may be, are the osteoblasts or bone formers, and the osteoclasts or bone destroyers. These cells are also active in repair of bone.

INFLAMMATION OF BONE.

Inflammation may occur in the covering membrane or periosteum of bone and is called *periostitis*. *Ostitis* is an inflammation of the marrow, and *osteomyelitis* is the term used when all parts of the bone are affected. Clinically it is quite difficult, especially in the bones of the face, to differentiate the two latter forms and the general term osteomyelitis is commonly used.

Etiology.—Causes of inflammation of bones are similar to causes of inflammation of other tissues. Traumatism and infection are the most common factors.

Periostitis.—Inflammation of the periosteum, or osteogenetic membrane, may be acute or chronic. In the acute cases the periosteum becomes swollen and exquisitely tender and the accompanying pain is usually quite severe. This condition is occasionally seen in the jaw after the injection of novocain under the periosteum, particularly when care has not been taken. If infection occurs, a subperiosteal abscess may result. The pericemental abscess so frequently seen along the root of a tooth or its socket is a good example of a modified periostitis.

Osteomyelitis.—The term used to describe inflammation of the bony structure itself. This may occur from a previously exciting periostitis or may be the direct result of accident or infection. This

condition is quite disposed to go on to formation of pus which tends to collect in cavities of the bone made by the destruction of the bone cells.

Necrosis of Bone.—The end-result of many cases of osteomyelitis. This takes place when the nutrition of the bone has been interfered with. The bone, as a result, loses its vitality and death or necrosis sets in.

The extent of the necrosis depends on the severity of the case. The portion of the bone that becomes necrotic is called the *sequestrum*. In the larger bones this sequestrum may occupy a central position, that is in the marrow cavity, and rarely this may be observed in the lower jaw, or the sequestrum may be a superficial or subperiosteal one.

Repair of Bone.—The repair of bone is similar in many respects to repair of soft tissue, but differs from it in several important points. Any dead or necrotic bone is much more resistant than soft tissue and the polymorphonuclear and endothelial leukocytes find it much harder to remove and absorb. As a result the necrotic bone persists for a much longer time in the lesion; acts as a real foreign body and interferes with repair so long as it is not removed either naturally or surgically. It may be dissolved very gradually by the action of endothelial leukocytes, many of which become fused to form the *foreign body giant cells* that appear so characteristically in this process. These are sometimes called osteoclasts because of the function they perform.

New bone is not found in a solid mass but in narrow trabeculæ with connective tissue richly supplied with blood between them. An excess of tissue is found during the process of repair which occupies more space than the healed bone will eventually occupy. Later these trabeculæ fuse more or less completely together and the parts not required are absorbed by the osteoblasts. In repair of a fracture of bone, osteoid material is found around the ends of the fragments at point of fracture in a sort of tumor mass which acts as a kind of splint. This formation is called *callus*. Later the excess tissue is removed so that the size of the bone at point of fracture is nearly the same as normal.

There is considerable difference of opinion regarding what tissue furnishes material for new bone growth. It is very well accepted that periosteum and endosteum function in this capacity and furnish fibroblasts that produce osteoid material which forms the basis for new bone. It was formerly thought that bone cells themselves cannot do this and many still hold to this belief. It is the opinion of competent observers, however, that new bone growth does not come entirely from the periosteum and endosteum but does come from the bone cells themselves.

Note.—In this discussion liberal use has been made of the masterly exposition of the subject by Prof. E. B. Mallory, to whom the author is deeply indebted.

CHAPTER VI.

DEPOSITS AND ACCRETIONS UPON THE TEETH.

By EDWARD C. KIRK, D.D.S., Sc.D., LL.D.

The factors involved in the composition and mode of production of deposits and accretions upon the teeth are those which are intimately connected with the chemistry, physiology and pathology of the saliva, the study of which is perhaps one of the most important considerations both in its scientific and practical aspects, that is engaging the attention of the dental profession, for it is through the study of saliva that we hope to ultimately solve some of the most important problems with which we have to deal in dental practice.

It has been mainly through the study of the saliva that we have arrived at some very definite ideas as to the causation of dental caries, and through the study of saliva we have also learned something of various other diseases to which the teeth and soft tissues of the mouth are subject, and it is through the study of the saliva we learn most about the deposits or accretions that are commonly spoken of as tartar and its mode of formation. After all, there is no phase of dental study that is of more immediate importance to those who are pursuing this course than that concerning the causes which lead to the formation of these deposits upon the teeth.

As for the word "tartar," some years ago in one of the popular magazines there appeared an article by a physician who stated that the tartar on the teeth was called "tartar" because it consisted of tartrate of lime. An eminent professor of chemistry once said to his class during a lecture that he never had understood why the sulphate of iron was popularly called copperas. He said he imagined it must have been called copper by the Dutch, because it had no copper in it. By the same mode of reasoning, it is probable that this medical man called these deposits tartar because there is no tartaric acid in them.

The term tartar was applied by the alchemist Basil Valentine to the deposits called argols in wine casks consisting essentially of potassium tartrate, and the acid derived therefrom was called tartaric acid or the acid of tartaros. Paracelsus applied the term much more widely to include earthy deposits from animal fluids such as calculus from the saliva. Tartar consists essentially of calcium phosphate or phosphate of lime and some carbonate of lime and corresponding magnesia salts held together by a binding material that we call mucin, a substance derived from the mucus of the saliva; that and some organic matter

such as food particles, and the bodies of dead bacteria, make up the bulk of what we call "tartar."

In order to understand the formation and deposition of tartar we must first know something about the saliva. By saliva we mean that mucoid fluid which we find in our mouths most of the time. It is is not always flowing, but our mouths and our food are lubricated and moistened by it. This saliva is manufactured by three pairs of glandular structures situated in the region of the mouth which pour their secretions into the oral cavity. The secretions of these several pairs of glands, which we speak of as the salivary glands, differ in their composition. Neither do all of these glands pour their secretion into the mouth at the same time, but under different circumstances and in response to different kinds of stimuli, namely, the stimulus of food or the stimulus of the thought of food or the stimulus of pain.

You are all familiar with the common expression that if we think of this or that kind of food it makes our "mouths water." This is literally true. Under the psychic stimulus of the thought of food, especially of food which is sapid or tasty, the salivary glands are encouraged to pour their secretions into the mouth, but it is interesting to note that different kinds of foods excite the secretion of different glands. For example, the physiological chemist Pavlow, of Petrograd, found that when a piece of fresh meat was offered to a dog the flow of saliva from the sublingual and submaxillary glands was stimulated, but not that from the parotid, which is a large gland situated in front of the ear.

When dry food, like powdered meat, was offered to the dog, the parotid salivary secretion was stimulated. So under different stimuli we find a response from different glands, and the response seems to stand in very close relationship to the character of the food that exerts the stimulus. This is an important relationship too, because dry foods, for example, need a great deal of moisture for two reasons: (1) For converting the food into a bolus so that it may be swallowed; (2) for furnishing sufficient water to the food in order to dissolve its soluble elements and to develop its taste. Tasty things stimulate the flow of saliva, and the watery secretion of the parotid gland is necessary in order to dissolve what is soluble in the food in order to bring out its taste. We cannot taste anything unless it is soluble, no more can we smell something unless it gives off a vapor of some sort. So that gratification of the sense of taste is secured by the solvent action of the parotid saliva, mainly, upon the foods that we take into the mouth and gratification of the sense of taste plays an important role in the cycle of activities that are related to normal bodily nutrition.

Besides the secretion of the salivary glands, the secretion of innumerable mucous glands that are imbedded throughout the whole oral or buccal mucous membrane, the lining membrane of the mouth, is added to the mixed saliva, and it is the secretion of these mucous glands

that gives to the saliva its slimy or slippery quality, owing to the substance mucin contained therein.

Mucin is a very important constituent of the saliva, among other things it has a very direct bearing upon tartar formation, but its main function seems to be that of a lubricant. Perhaps you all know of the peculiar technic of reptiles when they feed. A boa constrictor for instance, kills its prey, which may be a half-grown pig, and covers it with a slimy coating so as to lubricate this relatively enormous mouthful, and to render its passage into his interior as easy as possible. In a minor degree, the same function is performed by the lubricating exudate of the mucous glands of the mouth upon the bolus of food in the mouth of the human being.

Beside this important substance, mucin, the saliva contains also a peculiar ferment known as ptyalin, the function of which is to begin the digestion of starchy substances in the mouth. Starch as such is not utilizable as food by the body, therefore the ptyalin acts upon it, converting it by degrees into a kind of sugar, maltose. This predigestion of starch, or preparation for intestinal digestion, takes place in the mouth, hence the very great importance of thorough mastication of starches, which is doubtless the main justification for the fad of super-chewing that has spread over the country under the name of Fletcherism.

Another constituent of the saliva, though perhaps it is not of very great importance, has been exciting a great deal of comment in the past four or five years; that substance is known as potassium sulphocyanate, ordinarily spoken of as sulphocyanate. It may be questioned that it is a potassium sulphocyanate, but some kind of sulphocyante is present which is possibly a sodium or ammonium sulphocyanate. It has the peculiar property that when to a small quantity of saliva a drop or two of a test solution of perchloride of iron is added, if the sulphocyanate is present it causes a red or reddish coloration of the saliva. This reaction is rather dramatic, and has caused a great deal of discussion and debate as to its significance which thus far appears to be unimportant.

Sulphocyanate was at one time supposed to have a very important bearing upon caries causation, or of the prevention of carious action in the mouth, but recently it has been pretty definitely shown that sulphocyanate is an incidental constituent of the saliva, and that it has no significance except as a waste product of nutrition related to some other chemical activities in the body.

In addition to the constituents mentioned, saliva collected in a receptacle will show certain sediments, solid matter, if it stands for a short time. Just as the scarf-skin, or outer layer of the cuticle, separates from time to time, so does the mucous membrane of the mouth shed its epithelial coating into the saliva, and we find mixed with the saliva these epithelial scales from the buccal mucous membrane which when a specimen of saliva is allowed to stand for a time separate as sediment.

We find also as corpuscular elements, the leukocytes, or white blood corpuscles, which gain their way into the saliva. They have been spoken of as salivary corpuscles, but they are really white blood cells which have undergone certain changes of form.

As to the further chemistry of the saliva, if we take a measured quantity, and evaporate it to dryness, we find a small residue of solid matter. This residue consists of two kinds of substances, certain mineral salts which we speak of as the inorganic constituents of the saliva, and another kind of solid matter which is organic in character.

The total solids of saliva vary considerably in amount. It is difficult to say what represents the total quantity of solids in the saliva, but it is extremely small in amount, from about half of 1 per cent. to possibly 1 per cent. of the total saliva. These are only approximate figures, because the composition of the saliva varies constantly, depending upon the time of day when the sample is taken, how closely to a meal, whether after vigorous prolonged chewing, after drinking large quantities of water, or after abstaining from water for some time. Saliva becomes more concentrated the less water we drink, and it becomes more dilute in accordance with the quantity of water drunk.

The normal saliva in the ideally healthy individual, who has no caries of the teeth, no deposits upon the teeth and in whom the various functions are properly performed, the individual who is living up to the highest state of physical efficiency, in such a normal human being we can safely say the saliva is colorless, odorless and tasteless.

If the saliva develops either an odor or a characteristic taste, or a color, something is wrong; it is not a normal, but a pathological saliva; something has gone wrong with the individual; the chemistry of his body is not working properly.

When studying the physical appearance of a quarter- or a half-ounce of saliva collected in a test-tube, we find that in addition to its limpidity, its clearness or opalescence, a slight slimy quality due to the mucin and the presence of sediment, there is a covering of froth upon the top in which air is entangled. Besides which the saliva contains dissolved within itself a certain quantity of carbon dioxid. As we give off carbon dioxid from the lungs, so carbon dioxid is present to some extent in the saliva, and it gradually escapes on standing; hence the saliva in the test-tube soon loses its froth, the sediment settles to the bottom, and we have a column of this clear, odorless, tasteless substance above a layer of whitish sediment.

Any variation from these general conditions indicates ill health of some sort, or some error in nutrition, and the saliva is so sensitive, chemically, it reflects the variations in composition of the blood stream so accurately that we can utilize it for the study of the nutritional condition of the individual at the time when the specimen is taken.

It is a familiar fact that physicians have for years been studying the urine and the blood, as means for determining the condition of bodily nutrition, but investigation has brought forth the fact that the

saliva is almost as important an index of the condition of nutrition for the time being as either of these other fluids mentioned.

When the saliva is poured from the glands into the mouth it comes into an entirely new environment, that is to say, as it issues from the gland it is, comparatively speaking, sterile; it is not infected with bacterial elements, we do not find the bacteria in the saliva as it issues from the glands, but it issues into a cavity that is infected on all surfaces; in fact, it is poured into that portion of the human anatomy which is the portal of entry, for nearly all of the bacterial organisms that enter the body, and the saliva is necessarily subjected to the influence of these microörganisms.

The organisms that infect the mouth are not only myriad in number, but they are of an infinite variety and they produce different effects upon the saliva. Let us consider a little more closely the nature of that action in general. It is a familiar fact that if a quantity of milk, for example, is exposed to the atmosphere for a sufficient length of time, especially on a reasonably warm day, the milk in the course of time undergoes changes and becomes sour, as we say. First, it develops a sour taste, then becomes curdled, and if it is left to stand still longer the sourness disappears and it becomes putrid, developing a very disagreeable odor, as it undergoes decomposition. Modern bacteriology has settled the nature of these processes. They are processes of decomposition or of tearing apart of the various complex compounds that we find in milk into simpler substances.

Milk contains sugar, nitrogenous or proteid matter in the form of cheese, or casein, it contains water and fats. Each one of these substances seems to have a selective quality for certain kinds of bacteria, some of which attack the sugar, for example; others will only attack the caseous portion, the curd of the milk; other germs attack the fat. Butter, for example, when it becomes rancid, forms a particular kind of acid, butyric acid, as it is called. As the sugar element in the milk undergoes decomposition, it becomes sour just as the sugar in cider is converted into vinegar, or alcohol, as the case may be, through the agency of bacterial action.

Upon the same principle these various substances in the saliva, mucin, animal matter and sometimes sugar, which is formed by the action of the ptyalin upon starchy matter in the mouth are decomposed by the activity of certain special kinds of bacteria and produce what are designated in chemistry as typical or characteristic kinds of end-products, for example, acid substances; or they may produce ill-smelling substances, hydrogen or ammonium sulphide due to putrefaction or substances like ptomains or toxins which have a specific poisonous action upon the tissues with which they come in contact.

Incidentally caries or decay of the teeth is produced the same way. Thus we see the importance of the study of the saliva in relation to the manner in which it is decomposed through the agency of bacteria. From all this we may also deduce the immense importance of a clean

mouth, not only as regards the integrity of the teeth and the tissues about the teeth and the mouth itself, but as related to the general health of the individual. The question of a clean mouth is not a matter of sentiment alone, or a matter of aesthetics, but it is fundamentally a question of health.

Since decomposition of the saliva is brought about through the agency of a large variety of bacterial forms constantly inhabiting the mouth, and since the end-products of this bacterial action are so varied, and in most instances either poisonous, or capable of exerting corrosive action upon the tooth structure, it is evident that the best time to get rid of the conditions which result from these fermentative and putrefactive processes that take place in the mouth, is at the beginning, and that by doing so we can successfully prevent not only diseases of the teeth, but many diseases which affect the entire body.

In connection with the processes of decomposition through the agency of bacteria, a number of phenomena manifest themselves. In the first place, under certain conditions there is the production of a peculiar kind of deposit upon the teeth which has been spoken of as the bacterial plaque. The bacterial plaque is very important in many ways. In the first place, it represents the first step in the process of that disintegration of tooth structure which we call dental caries or tooth decay. Broadly speaking, we cannot have dental caries excepting through the agency of the bacterial plaque. Viewed simply from a physical point of view, a bacterial plaque is a deposit upon a tooth surface which localizes the process of decay. The function which the bacterial plaque performs in localizing the process of tooth decay at certain points is the factor which determines the principal characteristic of tooth decay, namely, that of cavity formation.

Let us for a moment examine the nature of this deposit called the bacterial plaque. Recall for the purpose of this argument the fact that the saliva contains first of all mucin in solution. In order to have a solution of mucin in the saliva we must have an alkaline reaction of the saliva, because mucin is not soluble in an acid fluid. If we take a specimen of saliva and add a drop of any kind of acid to it, acetic acid, lactic acid, sulphuric acid, citric acid, etc., we shall immediately see what we call a precipitate which looks as if something in the saliva had been cooked, as in the cooking of the white of an egg. That happens instantly when mucin comes in contact with any acid.

One of the acids which is most prompt to cause the precipitation of mucin is lactic acid, the acid that is produced when milk sours. Lactic acid is instantly produced in the mouth by the action of certain forms of bacteria upon sugars found in or taken into the mouth.

Sugars, as we know, are produced in the mouth by the action of the ptyalin of the saliva which converts the starch into sugar. As long as sugar is thus formed certain classes of bacteria act upon it and split it up into lactic acid. These lactic-acid-producing organisms being constantly present, fermentation goes on and lactic acid is produced

as long as there is something for the organisms to live upon. Just the moment that a point (considering a bacterium as a point) of acid production is set up in the saliva there occurs a precipitation around that point of insoluble mucin, and when the action is started by the lodgement of lactic-acid-producing organisms upon a tooth surface where they may develop and multiply undisturbed in protected locations the process continues until what we call a bacterial plaque is formed. These plaques are localized upon all tooth surfaces that are protected from the friction of food or of the tongue or lips, and in places that are not kept thoroughly polished and clean, especially in the class of mouths that are susceptible to dental caries.

It will be readily understood that the acid which is manufactured at the point localized by the bacterial plaque is constantly disintegrating the tooth structure upon which it has formed and breaking it down. Thus we have a deposit produced from the saliva and from conditions existing in the saliva which is the first step in the process that we speak of as dental caries.

The plaques are not ordinarily visible to the naked eye, but there has been introduced[1] what is denominated a "disclosing solution" containing iodin, which renders them visible. By applying tincture of iodin to mucin we secure a color reaction, that is to say, it produces a brownish or reddish-brown tint deeper than that of the iodin, especially if certain of the sugars, maltose, for example, be present. If we paint the tooth with iodin or spray it with a solution of iodin, in the course of time we will find that the iodin has stained certain portions of the tooth to a darker tint than others, owing to the fact that the plaques have taken up the iodin, combined with it and formed a dark brownish stain. The formula of Skinner's disclosing solution is as follows:

Iodin crystals	50 grs.
Potassium iodid	15 grs.
Zinc iodid	15 grs.
Glycerin	4 dr.
Water	4 dr.—M.

As an adjuvant to the disclosing solution, however, another step or stage has been suggested by H. C. Ferris, and that is, the spraying of the surface, after it has been treated with the iodin solution, with a boiled starch solution. It should be remembered, however, that starch and iodin, no matter how they are put together, produce a very dense blue color, and unless one is careful in making this test, the starch may apparently disclose plaques where they do not exist. Hence the tooth should be rinsed thoroughly before the application of the second member of the disclosing solution is made in order to remove excess of iodin. As a matter of fact, a plaque is disclosed with sufficient clear-

[1] F. H. Skinner, Dental Cosmos; 1912, p. 43

ness by the use of the ordinary official tincture of iodin, 7 per cent., without subsequent application of starch solution.

There may be other sources of plaque formation, but the explanation given indicates the general principle which accounts for these soft, slimy, fairly adhesive deposits upon the teeth, which can be readily rubbed off by the application of fine pumice on an orange-wood stick, if the rubbing and polishing is thoroughly and carefully done. It does not require the instrumentation that we speak of as "scaling" to remove deposits of this class.

In the precipitation of mucin by lactic acid we have the general principle involved in practically all of the deposits of that character. These may be localized or there may be a general precipitation of mucin upon the teeth, carrying with it particles of food or débris of various sorts, which, if not removed, condenses, grows harder, more tenacious and more difficult to remove, though when first deposited it is very soft in character.

We come now to a consideration of an entirely different class of deposits which are of the true tartar type, namely, the mineral deposits upon the teeth. The formation of tartar is a most complicated process and constitutes one of the puzzles of the chemistry of the mouth. What we do know about it is this: Chemical analysis of these hard deposits called tartar shows them to consist mainly of calcium phosphate, some calcium carbonate, the bodies of dead bacteria, débris of food, food particles, all bound together by mucin.

An English investigator, Mr. Rainey, about fifty years ago, undertook a study of the mode of formation of shells of various sorts, and he was led into some experimentation with reference to the changes that take place in certain kinds of earthy precipitates like carbonate of lime under varying conditions, as for example, when these earthy substances were precipitated in a solution which contained a material like gelatin, gum arabic or egg albumen, or what is termed in chemistry, colloidal substances. He found that the carbonate of lime was precipitated from a watery solution in a more or less crystalline character, but if the smallest quantity of glue, albumin, gelatin or other glue-like substance, was added to the water in which the precipitation took place the deposit instead of being of a crystalline character was made up of little spherical bodies that were more or less translucent. The precipitate formed very slowly and this investigator found that these minute globular masses side by side tended to increase in size by additions to their exterior, this increase in size continuing until two of these bodies would come together and coalesce; then another one would grow up to this mass and they would coalesce, so that gradually it assumed the appearance of a mass of marbles glued together or, of a mulberry mass.

This investigation led others to continue the observations and finally it was shown that the process of precipitation and molecular coalescence is at the bottom of a number of very important processes

not only in the human body, but in the mode of growth of the shells of mollusks and the pearl formation in the oyster, for example. On further investigation it was found that the pathological conditions that involve stone-like concretions in the kidney or the bladder, concretions of a calcareous character that are found sometimes in the ear and various parts of the body, or in old abscesses that have undergone repair, all arose after the same principle of coalescence of the precipitate of an earthy salt in combination or in contact with a colloidal or glue-like basis which acted as a binding material.

Precipitations of the earthy salts, phosphates and carbonates, that were held in solution in the saliva, when they take place in the human mouth, combine with the glue-like substance in the saliva which we have spoken of as mucin, and are bound together by the mucin to form the mass called tartar which deposits itself upon the teeth. Tartar varies in a great many ways; it varies in the rapidity with which it forms, it varies in the position in which it is deposited, and above all it varies in its density, the tenacity with which it adheres to the tooth surface and its toughness.

FIG. 92.—Specimens of parotid tartar; actual size.

Certain classes of tartar undergo very rapid formation and enormous development. Masses of tartar weighing as much as from two hundred and fifty to three hundred grains are reported. It seems incredible that any human being could tolerate in his mouth a mass of tartar larger than a pigeon's egg attached to the buccal surface of the molar teeth, yet such instances are by no means infrequent. Tartar which is formed rapidly and in large masses is usually relatively soft and friable and can be readily removed by proper instrumentation.

Every dentist has had patients with the idea in their minds that tartar was protective to the teeth and for that reason they objected to having it removed. It is true to a great extent that teeth upon which that kind of tartar is deposited rarely decay, not because the tartar is protective, but because conditions that cause the deposition of the tartar are precisely the opposite of those that favor caries of

the teeth. When such enormous accumulations are removed from the teeth the patients are often surprised that the teeth do not come out with the removal of the deposit.

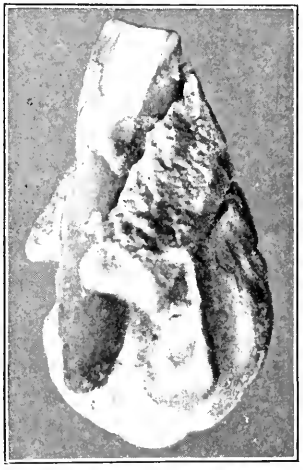


FIG. 93.—Sublingual tartar on a lower incisor.

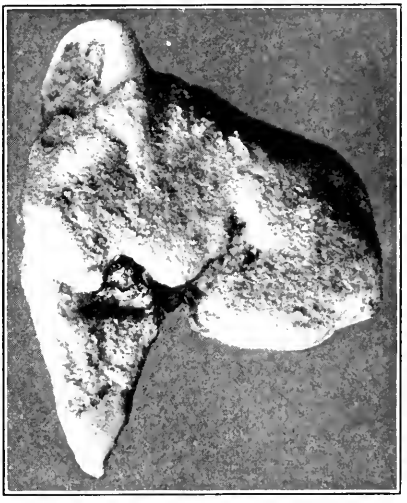


FIG. 94.—Sublingual tartar on a lower canine.

This kind of tartar will form upon artificial dentures just as readily as upon the surfaces of the natural teeth, and it is usually found at

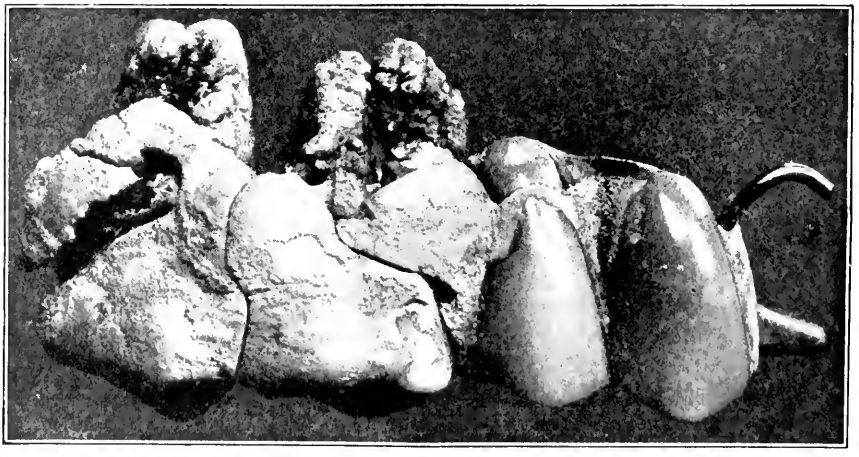


FIG. 95.—Partial denture clasped to first and second molars, which have been lost by deposition of parotid tartar.

positions opposite the orifices of the ducts of the salivary glands. For the same reason we find these enormous masses ordinarily upon

the buccal surfaces of the molars and upon the lingual surfaces of the lower teeth occupying positions almost opposite the openings of the salivary ducts (see Fig. 95).

The question of why this is so is the chemical problem that we are confronting. This is what we know: that calcium phosphate as it exists in tartar is not the same kind of calcium phosphate that exists in solution in the saliva; that is to say, after it reaches the mouth it undergoes some chemical change, the nature of which may be illustrated as follows: One of the popular drinks advertised at the soda fountains is "Acid Phosphate." Calcium phosphate or lime phosphate, chemically speaking, is a term applied to a group of compounds of which there are two distinct kinds. One contains more lime in proportion to the phosphoric acid than does the other. The one which contains less lime in proportion to the phosphoric acid is designated as acid phosphate, which is soluble in water, and has acid properties; whereas the other phosphate which is designated as basic phosphate contains a larger proportion of lime and is insoluble in water.

If we add to the acid phosphate a little more lime, we convert it into basic phosphate; and because of its relative insolubility it would fall out of solution as a sediment or precipitate. A similar process occurs in the deposition of this phosphate as tartar in the mouth. It is in a state of acid combination in the saliva. Possibly it is the content of carbonic acid in the saliva which holds the phosphate in solution, and when the carbonic acid escapes from the saliva, the phosphate, having nothing to hold it in solution, falls down as a precipitate.

Mucin acts as a glue-like binding material to the small earthy particles of phosphate and fastens them together and when the proportion of mucin to the calcium phosphate is in certain ratio the mass may be so dense and adhesive that it is almost impossible to cut it with a steel instrument or scrape it from the tooth surface.

The escape of carbonic acid is one of the means by which we think the earthy materials of the saliva are precipitated. If we take any alkaline substance into the mouth, thereby adding free alkali to the saliva, we are likely to cause a precipitation of the lime salts.

There is always a certain amount of ammonia, produced by the chemistry of nutrition, that issues from the lungs with the expired air, and if there is enough ammonia produced in a given case to impart a definite free alkalinity to the saliva, then precipitation of the lime salts takes place or ammonia may be produced in the mouth by putrefaction, decomposition of animal substances causing tartar formation in unclean mouths.

There is another suggested mode of tartar formation. Dr. H. H. Burchard found that when fermentation is going on in the mouth with production of lactic acid in small quantities the mucin is precipitated and the coagulated mass of mucin tends to gather within itself these earthy salts, just as a net drawn through a stream would gather

up fish; this mass is deposited upon the teeth, and condenses more and more, forming tartar.

Tartar has been thus produced artificially out of the mouth, by taking saliva rich in calcium salts and adding small quantities of dilute lactic acid, causing precipitation when a hard material of a dark greenish shade is produced, physically similar to the deposits that we find upon the teeth.

One of the most interesting examples of tartar formation is that observed upon the teeth of the natives of Indo-China and the Malay Archipelago. They are habituated to the chewing of the betel nut. This use of the betel nut as a masticatory is very prevalent throughout Indo-China and the Malay Archipelago.

Habitual chewing of the betel nut, in the course of a short time, causes the teeth to become stained to a very dark reddish brown of about the color of the exterior of a chestnut, and enormous deposits of tartar quickly aggregate, so that the teeth become distorted in appearance and position and are very quickly lost from their sockets. It is not infrequent that young people not over twenty-five years of age are rendered completely toothless by the habit of betel-nut-chewing.

The shavings of betel nut are wrapped up in pieces of the leaf of a certain kind of plant called Penang pepper, along with some aromatic spices such as catechu or cloves, or cardamom seed, according to the taste of the betel-nut-chewer, to give it an aromatic flavor. Then about the quantity of half a small spoonful of lime, made by burning oyster shells, is sprinkled all over this mass to develop the flavor. This morsel, rolled up in the green pepper leaf, is very carefully tucked away in the cheek. It causes a free flow of saliva tinged with a red color. The addition of the lime, which develops the flavor, is what causes the trouble. The acid or soluble phosphate of lime in the saliva upon the addition of this extra lime, is converted into the insoluble form of phosphate and precipitated on the teeth (Figs. 96, 97 and 98).

The foregoing is an example of the formation of tartar due to change in the chemical composition of the lime salts of the saliva from a soluble form into an insoluble form.

The hardness of the tartar depends upon the amount of its lime constituent as related to the mucin constituent. The hardest formations of tartar contain more of the glue-like or mucinous element than do the more friable and easily broken-down forms. The hardest tartar formed is found just under the gum margin. The large masses that are attached to the free surfaces of the teeth opposite the ducts of the glands are usually soft and easily removed regardless of size, but the rings of tartar underneath the gum margin, the hard scales of tartar, are the most difficult of removal. It is this kind of tartar that contains the largest proportion of organic binding material, because the deposit of tartar at that point sets up an irritation of the gum tissue and causes the weeping out from the gum tissue of the

albuminous, serous portion of the blood which combines with this deposit and forms a very hard, tenacious mass.

FIG. 96.—Lower incisor almost completely encrusted with betel tartar.

FIG. 97.—Lower canine covered with betel tartar.

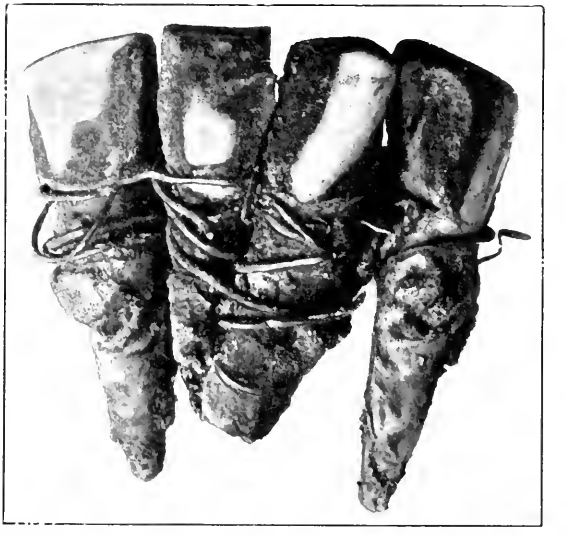


FIG. 98.—Lower incisors lost from deposit of betel tartar. As they gradually loosened from the encroachment of the tartar they were bound together with fine brass wire by a native dentist, to give them firmness by mutual support.

Farther down upon the roots of the teeth we frequently find deposits of another form of tartar, which is probably not salivary in origin. It is spoken of as serumal tartar and is derived from the serum of the blood. From a chemical standpoint it is practically a formation of the same character but it originates differently. So far as we know, this serumal tartar which is situated deep down upon the roots of the teeth and not connected with saliva in its origin, is the result of some primary inflammatory conditions upon the tooth root. It is not necessary to go into the causes of such preceding inflammatory conditions which, instead of breaking out as abscesses, have healed spontaneously by what we call the process of resolution, by which is meant that the bacteria which set up the inflammation have died. They have been killed by the resisting forces of the body itself and the inflammatory process has stopped, and the tissues have undergone repair, but the dead bacteria and the broken-down tissue constituting pus has gradually become dehydrated, and there is left a cheesy mass which later on has become saturated with lime salts derived from the blood stream itself. These lime salts combine with this cheesy mass resulting in a tartar-like formation in which the cheesy mass of colloidal organic matter takes the place of the mucin in saliva as the binding material.

Tartar formed in that way is a mechanical irritant to the surrounding tissues, making them subject to subsequent infections. The tartar acts as a foreign body in the tissue setting up irritation, infection follows and the process is repeated with continued growth of tartar, or the abscess may break at the gum margin and a pyorrheal pocket may thus be formed. The pus pockets in pyorrhea may be formed from the root to the gum margin or from the gum margin rootward.

Two other phases of this subject are of importance: one is the color of the tartar, the other is the solubility of the tartar. Tartar we find to be of different colors. The tartar which forms rapidly is soft and friable, salivary in origin and more nearly colorless than any of the other varieties. It is nearer in chemical composition to a simple precipitation of phosphate of lime. But when it forms slowly and under the margin of the gum we usually find it highly colored. It must always be remembered that tartar precipitated around the necks of the teeth is a mechanical irritant to the soft tissues of the gum margin. This irritation predisposes to bacterial infection, which leads to an inflammatory process and, as the inflammation proceeds, more or less blood weeps out from the irritated tissue in contact with the tartar. The tartar is then colored by what we call the hemoglobin or the coloring matter of the red blood corpuscles. In other words, the color of the darker varieties of tartar is derived from the coloring matter of the blood which undergoes a variety of changes in color when it is subjected to the processes that lead to its decomposition.

It is a familiar fact that a black eye, or any black-and-blue pigmentation of the skin surface due to a bruise is at first red, then grows

a little darker because the coloring matter from the blood has wept out into the surrounding tissues; then it undergoes chemical decomposition, with a variety of color changes, until it becomes very dark. In the same way when blood oozes out from the gum margin and comes in contact with the tartar this coloring matter is absorbed by the tartar, becomes part of its binding material and undergoes color changes which are quite analogous to those observed in a bruise, that is, from a reddish or brown tint through a variety of color changes down through brown and blue to a final grayish or greenish, almost black, appearance.

Tartar may be pigmented from other causes. It may be pigmented through the activities of certain bacteria that are color-producing, or it may be pigmented by the character of the food or other material that is taken into the mouth as in the case of the betel-nut-chewer, or as in the case of tobacco-chewers or smokers.

The solubility of tartar is an important consideration from a practical point of view. We have had to depend thus far almost altogether upon mechanical instrumentation for the removal of these deposits, for the reason that we have had no proper solvent for this material, something that will disintegrate it without endangering the texture of the teeth. The enamel of the teeth is composed of the same mineral ingredients as tartar, namely, calcium phosphate and a little carbonate. Therefore, generally speaking, a solvent of tartar will necessarily also be a solvent of enamel, and it is a very difficult proposition to apply a solvent to the tartar without damaging the teeth.

There are instances, of course, where the importance of the removal of tartar in certain positions may warrant that risk, if the solvent is applied intelligently and quickly neutralized if it tends to affect the teeth detrimentally. But, broadly speaking, the chemical problem is to find something that will dissolve tartar, but will not dissolve the tooth structure. We would be safer if we could find some chemical solvent that would dissolve, not the calcium phosphate, but the binding material that holds the calcium phosphate together, *i. e.*, the mucin; but the calcium phosphate is soluble in acid, while the mucin is not. Mucin is soluble in alkali while calcium phosphate is not soluble in alkali, at least in any such strength as can be borne in the mouth. So we are confronting a very delicate problem. It is like trying to use a germicide strong enough to kill bacteria without killing the individual that is infected by them; to find an agent selective in its action, so that it will damage the germ and not damage the host of the germ.

Certain substances have been used as tartar solvents with a fair degree of success. Lactic acid has the property of dissolving the calcium phosphate and of forming soluble salts of calcium phosphate and may be applied as a tartar solvent. It is not a vicious acid in attacking the tooth structure, and may be applied to remove the last particles of tartar after the bulk has been removed mechanically by

instrumentation. Solvents should not be used for the removal of the bulk of tartar deposits; they are indicated only for the removal of the last remnants. It should never be forgotten that all the other pieces of tartar are of minor, even negligible importance as compared with the last piece. A man may walk one hundred miles and take many thousands of steps through storm and weather to reach his home, but if he does not take the last step over the doorway, he is not home yet. He may die before he lifts the latch. He has not reached his destination. All his previous steps count for nothing.

It is quite the same with reference to the removal of deposits. It is the last one that counts, and when that is removed the work is done. The last fragment of tartar sometimes even the most delicate tactile sense may fail to detect, especially if it is situated down toward the end of the root of a tooth, or in a pocket which has been thoroughly gone over with the instrument, yet one is not sure whether a small particle has not been left. It is in such a place that we may have recourse to the use of a solvent such as lactic acid.

A word should also be said about the solubility of the bacterial plaque. As this plaque is produced mainly by precipitation of mucin by acids, it is perfectly soluble in alkalies. The alkali that is a natural solvent of mucin precipitated by acid is calcium hydroxide, the solution of which we ordinarily speak of as lime water. A solution of three parts of lime water with one part of hydrogen dioxid has greater efficiency than lime water as a means of removing the bacterial plaque. The lime water renders the mucin soluble so that it can be washed off the teeth, and the hydrogen dioxid disintegrates the plaque, so that this solution has a doubly favorable action. It should be used habitually as a dentifrice by all patients who are known to be constitutionally susceptible to caries.

The sources of the discoloration of tartar to which I referred are also the sources of the discolorations that we find on teeth, especially in children, which are spoken of as green stain or brown stain. There are two sources. The coloring matter of the blood is the proteid substance called hemoglobin. When in solution in the course of a short time, this color undergoes a change, becoming bluish or more purplish in color as the hemoglobin decomposes. In the course of further decomposition it assumes a greenish tint. This color change can be effected much more quickly by adding hydrogen sulphide to the blood. Hydrogen sulphide is produced by decomposition of albuminous matter, as in the decomposition of an egg, which then gives off that peculiar odor of hydrogen sulphide, which is due to the decomposition of the sulphur elements in the albumin, and it is the hydrogen sulphide arising from decomposition of the albuminous or proteid elements of the blood acting on the hemoglobin that changes its color to a dirty greenish tint.

In cases of irritation of the gum margin, a little of the coloring matter of the blood weeps out, chemical changes go on through the

agency of mouth bacteria, the albuminous portion of the saliva and the blood putrefies. Hydrogen sulphide is given off, the sulphur compounds unite with the coloring matter of the blood and produce the green or greenish-brown stain observed on children's teeth and the teeth of those having irritated and bleeding gums in uncleanly mouths. The chemical make-up of the pigment of that stain is the decomposition product called sulphomethemoglobin. The children's teeth upon which it is observed are not properly kept clean. They have a history of lack of practical acquaintance with the toothbrush and the technic of the ordinary dental toilet.

Another of these green stains is in all probability due to pigmentations of the normal covering of the enamel of the young tooth, which we speak of as Nasmyth's membrane, by certain color-producing or chromogenic bacteria bringing about that characteristic color.

By treating the young tooth with very dilute acids we can isolate Nasmyth's membrane and examine it under the microscope, when we find it permeated with what looks like the result of bacterial activity.

Both these types of green stain upon the tooth surface are readily removable by the application of iodin, and the subsequent use of polishing powders or pumice applied on an orange-wood stick. Iodin is not only an antiseptic, but also a bleaching agent. That sounds very peculiar, because it stains of itself, but we can stain the surface structure of a tooth to a deep tint with iodin and simply let it alone, and when the patient returns the next day that tooth will be much lighter in color, due to the bleaching action of the iodin. We need never be afraid of permanently tinting a tooth with iodin, unless we apply it with a steel instrument, when iodid of iron is formed and a permanent stain will be produced. Iodin itself may be used with perfect freedom upon tooth surfaces free from metallic fillings for the reason that it is ultimately a bleaching agent.

CHAPTER VII.

PYORRHEA ALVEOLARIS

By ARTHUR H. MERRITT, D.D.S.

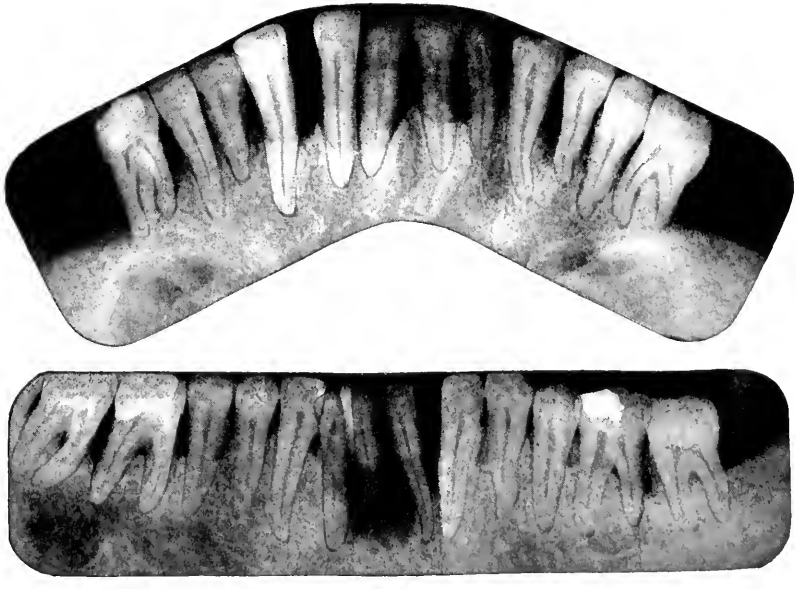
Definition and History.—Pyorrhea alveolaris is a disease affecting the teeth and their investing tissues. It may be defined as a progressive resorption of the alveolar process and pericementum with a coincident shrinkage and recession of the gums, accompanied by increasing loosening of the teeth. It is a disease as old as civilization and may be older. There is abundant evidence that it existed among the early Egyptians, Greeks, Etruscans, Phœnicians, Romans and Chinese. Frequent mention is made in their literature of "loose teeth," "bleeding gums," etc., with their discharge of "corruption." Some attempt at treatment was made, usually in the form of absurd mouth washes, despite the fact that it was generally regarded as incurable. In this country about 1845, John M. Riggs of Hartford, Conn., was the first to publicly call attention to the disease and to assert that it was a curable disease, and that by proper surgical treatment 90 per cent. of all cases could be cured. He achieved a considerable reputation in his generation and was quoted at home and abroad as an authority on the subject. As a result, the disease came to be known as "Riggs' Disease" though this name was not given to it by Riggs himself. Prior to this it had been referred to as loose tooth, spongy gums, scurvy, etc. In 1877 F. H. Rehwinkel gave to it the name of pyorrhea alveolaris, in a paper which he read before the American Dental Association. This name, which was not original with Rehwinkel, having been borrowed by him from European writers, has never been wholly acceptable, having been severely criticised since its introduction. It means, literally, a flow of pus from the alveolus, and is therefore descriptive of one phase only in its pathology. Many attempts have since been made to give it a more appropriate name, but without complete success; it still remains the name by which it is most generally known. For that reason it is used here, notwithstanding the fact that the name of periodontoclasia, given to it by the American Academy of Periodontology, is more in harmony with its pathology in its various manifestations.

Pathology.—Pyorrhea alveolaris is a disease which begins, as a rule, at the gingival border, and progresses slowly toward the apex of the root, resulting in a complete destruction of the alveolar process and pericementum with eventual loss of the teeth unless arrested by treatment. Some of the phenomenon attending its progress are gingival inflammation, solution of continuity in the floor of the gingival crevice,

absorption of the alveolar process, pocket formation, suppurative infection, sensitiveness to thermal changes, separation, elongation and loosening of teeth. Of these, the first to manifest itself is gingival inflammation induced by various causes, the most common of which is uncleanliness of the mouth. Irritation of the gingiva from any cause, if long enough continued, results in inflammation which in time may be conveyed through the gingival group of pericemental fibers to the pericementum, eventually causing a break in the floor of the gingival crevice. Coincident with this break, the cementum, pericementum and alveolar process are exposed to the destructive forces of irritation and infection. A phenomenon known as halisteresis is set up in the alveolar process, by which it is slowly absorbed. The rapidity with which these changes occur will depend upon several factors—the thickness of the bone, the resistance of the patient, the cleanliness or uncleanliness of the mouth, etc. As a rule its progress is slow, often many years elapsing between the initial gingival irritation and final loss of the teeth.

Pyorrhea alveolaris manifests itself in a succession of symptoms. Usually beginning as a mild gingival irritation which may exist for years without further changes, it finally involves the subjacent tissues, slowly destroying the pericemental attachment at the gingivo-enamel junction, absorbing the alveolar crest and slowly advancing toward the apex of the root, destroying the alveolar process and pericementum as it progresses. This may occur symmetrically around the root, or, as more often happens, along one side only. The destruction of the alveolar process and pericementum is followed by shrinkage and recession of the gums, though this recession never keeps pace with the bone resorption. The result is the formation of a pocket, bounded at one point by the extreme limits of bone necrosis, and at the other by the margin of the gum. The depth of this pocket will depend upon the amount of bone loss and gum recession. Laterally they are bounded on the one hand by the surrounding vascular tissues and on the other by the cementum with its investment of necrotic pericementum and calculary deposit. Into these pockets, even in their earliest beginnings, the bacterial flora of the mouth finds its way. These organisms are secondary invaders only, having no direct etiological relationship to the disease. Comparative studies of the bacterial flora of these pockets show that they do not differ qualitatively from that of the normal mouth. There is, however, great quantitative difference, this being explained by the fact that these conditions are more favorable to bacterial growth than are those of the healthy mouth. This flora is a mixed infection of great complexity. There is no evidence that any of these organisms sustain a direct causal relationship to the disease. They are, however, responsible for one of its characteristic symptoms of pus discharge. These bacteria may also give rise to secondary infections of a serious nature, in many instances contributing to the ill health and inefficiency of the patient, and not infrequently are the

FIGS. 99 and 100.—Panoramic radiographic view of a normal denture, to show especially the height of the bony alveolar septi between the teeth, for comparison with other radiographs in which destruction of the bone has occurred.



FIGS. 101 and 102.—Panoramic radiographic view of the upper and lower jaw in a case of pyorrhea of long standing. Note the amount of bone that has been destroyed by the progress of the disease.

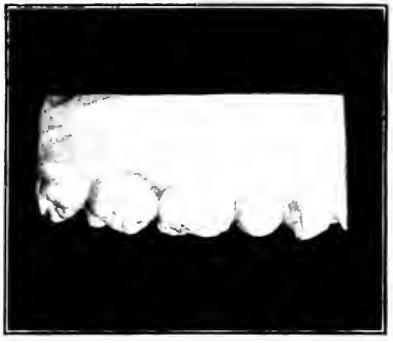


FIG. 1

FIG. 2

FIG. 3

FIG. 4

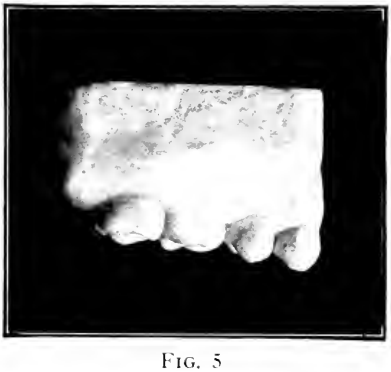


FIG. 5

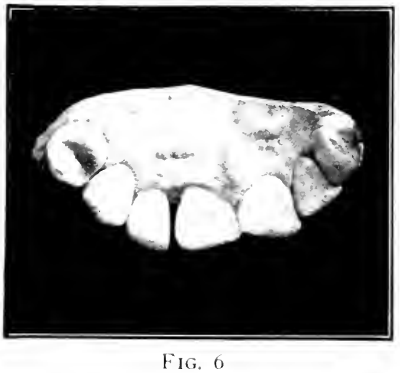


FIG. 6

Cases of Gingivitis and Incipient Pyorrhea.

Note defective contact points, loss of septal gingiva and recession of gums; also abscess due to pyorrhea in Fig. 5. All caused by irritation from food impaction.

indirect cause of death. About one thing there can be no doubt, namely, their potentiality for evil is an inherent quality, dependent only for its exercise upon the virulence of the organisms and the resistance of the patient.

Etiology.—Pyorrhea alveolaris has a variety of causes, most of which have their origin within the mouth. They have one characteristic which is common to them all in that they are irritative in their nature. These causes may be divided into two classes—those which begin at the gingiva and by slow progression involve the entire supporting tissues of the teeth, and secondly those which affect primarily the pericementum and alveolar process. Of these the more obvious, and also the more common, are those begining at the gingival margin of the gums. Anything which irritates the gingiva must be regarded as a potential cause of pyorrhea. Uncleanliness of the mouth, food impaction as a result of defective contact points, overhanging edges of fillings, ill-fitting crowns, bridges, etc., are all causes of gingival irritation. Of these the most common and potentially the most dangerous, is uncleanliness of the mouth.

The second form of irritation, that which affects primarily the deeper periodontal tissues, is traumatic occlusion. This may be defined as a lack of harmony between the inclined planes of opposing teeth when brought into occlusion in the act of mastication, as a result of which the teeth are driven outside their normal limits of motion, and subjected to a lateral strain, which if long enough continued, causes definite changes in the pericementum and alveolar process with coincident loosening of the teeth. This may exist in teeth with normal occlusion in the usual meaning of the word, that is, straight teeth, and is a very common cause of pyorrhea; it and bad hygiene being the chief causes.

It is also possible that under certain conditions heredity, diet, constitutional diatheses, etc., may predispose to pyorrhea, or may unfavorably influence prognosis. These conditions, however, are not common as shown by the fact that most cases yield promptly to local treatment when properly employed.

Prevention.—There are probably no diseases of a chronic nature occurring in the mouth more easily prevented than is pyorrhea alveolaris, or none where prevention is of more value. Its treatment in advanced cases is always difficult, and the prognosis often doubtful. All such cases begin as a simple lesion, which with all its unfortunate consequences might have been prevented had proper care been observed. As stated, this lesion usually, if not always, begins at the gingiva, caused by some irritation of this organ, the most common of which is uncleanliness of the mouth as expressed in food accumulations, tartar, debris, bacteria, filth, etc.

If a careful examination be made of the free gingivæ, it will be found that they project themselves above the alveolar crests often to the extent of several millimeters. Between the free gingiva and the cervical enamel is the gingival crevice, bounded at the cemento-enamel

junction by the attachment of the gingival group of pericemental fibers. In health the free gingivæ terminate in a thin edge which hugs the cervical enamel in such a way as to protect this pericemental attachment against injury. If, as a result of irritation, this knife-like edge, so admirably adapted to its purpose, becomes inflamed, its protective property is more or less seriously impaired. It no longer permits food to glide over it without injury in the act of mastication, but a certain portion of it is forced into the gingival crevice, thereby adding to the already existing inflammation. Wherever inflammation of the gingivæ exists, the quantity of the serum normally secreted into the gingival crevice is increased, and if it contains calcoglobulin, serumal calculus may be deposited. This deposit, so often found in the gingival crevice, is not the cause, but the effect of gingival irritation, though it may in its turn act as an irritant. The importance, therefore, of protecting the gingivæ against irritation must be obvious. They stand as protective barriers to the subjacent tissues of the teeth, including that most vulnerable point, the pericemental attachment. Their preservation in health is essential to the proper function of the teeth; to conserve and protect them against injury is of the first importance.

This is the work to which the dental hygienist is called, and there is none more worth while in the whole field of dental practice. It is a service of far more value to the patient than any restorative measures which may be employed to replace these teeth after they have been lost, just as preventive treatment is always of more value than curative. She has within her power the prevention of two of the most common diseases which afflict mankind—dental caries and pyorrhea alveolaris, diseases so nearly universal as to affect all races and all ages. The first of these can be reduced to a minimum by oral hygiene; the second can be almost completely prevented by the same measures. To accomplish this the gingivæ must be maintained in health; nothing must be allowed to irritate them. Each gingiva should be carefully examined and the slightest abnormality in form or color noted, and its cause sought out and removed. This cause will be found to be something which irritates—usually something acting from without, such as an unclean mouth, defective contact points, which permit of food impaction, overhanging edges of fillings, crowns, bridges, etc. Certain chemical poisons acting from within, of which mercury and potassium iodide are examples, may also irritate and inflame the gingivæ, as may certain poisons which result from nutritional disturbances, but these are uncommon and almost negligible factors. The really important thing is that they be protected against external irritants, which is best accomplished by thorough and painstaking cleansing of the teeth. This involves more than a perfunctory polishing of the enamel surfaces. Every gingival crevice should be explored and its contents removed. In those cases in which solution of continuity has taken place in the floor of the gingival crevice, and the subjacent tissues have become involved in disease, treatment by the dentist is required. The more

valuable service of prevention falls within the province of the dental hygienist.

Treatment—Pyorrhea alveolaris is a curable disease, though it may reach an incurable stage if long enough neglected. Its treatment belongs exclusively to the dentist. The dental hygienist, however, should be familiar with the approved method of treatment and able to express an intelligent opinion on the subject. She can be of great assistance to the dentist in helping to maintain a high degree of oral cleanliness, always a prerequisite to the best results. Its treatment is essentially surgical, a fact first announced by Riggs more than three quarters of a century ago. This consists in the complete removal from the denuded cementum of all calcareous deposits, including also the necrotic pericementum. In some instances, curettage of the affected alveolar process may be necessary. When traumatic occlusion is present, as is often the case, this must be corrected by judicious grinding of the occlusal surfaces of such teeth. Treatment in advanced cases requires an exacting and painstaking technic. The absolute necessity of cleansing the involved cementum of all foreign and necrotic material, makes the operation an exceedingly difficult one. Failure in this respect means unsatisfactory results, which explains why it is that so many are unsuccessful, and explains also why so many are pessimistic regarding its prognosis and treatment.

When, however, proper methods of treatment have been employed, the most gratifying results are achieved. Health is reëstablished in the involved tissues, the teeth tighten in their sockets, the gums resume their normal color and become firm about the teeth, in some instances reattaching themselves to the roots, thereby completely obliterating the pockets. This, however, does not occur about non-vital teeth that have become septic, nor about vital teeth upon which poor root surgery has been practised.

Postoperative treatment requires the maintenance of a high degree of mouth cleanliness. The patient must be instructed in correct habits of tooth brushing and provided with proper tooth brushes, dentifrices, waxed silk tape, etc. This should be supplemented by periodic cleansing by the dentist or hygienist, the frequency of which will depend largely upon the efficiency of the care given by the patient; three to six months' intervals will be sufficient in most cases. Mouth washes, drugs, vaccines, etc., have very little place in the prevention and treatment of pyorrhea. Dependence must be placed upon normal occlusion and mouth hygiene, not forgetting that anything which irritates the gingiva is a potential cause of disease in these tissues.

Summary.—If now a summary be made of present-day knowledge regarding pyorrhea and its treatment, certain facts stand out clearly. Pyorrhea is not, as it is believed by some to be, a disease of modern life, but is as old as civilization itself. It expresses itself in many forms, beginning, as a rule, at the gingival margin, and by extension,

slowly involving all of the supporting tissues of the teeth, and thereby causing their final loss.

Its causes are usually found within the mouth itself, and may be anything which irritates the gingivæ, the most common of which is uncleanliness of the mouth. It is a disease which in most instances can be prevented when proper care is observed by both patient and dentist. To achieve this it is essential that the gingivæ be kept from irritation. Oral hygiene in its broadest sense is the best means to that end. Pyorrhea is a curable disease if taken in time. Its treatment is surgical and depends for success upon the thoroughness and skill with which the operation is performed. As a rule, its treatment is not painful. Mouth washes and drugs have no place in treatment. This applies to the hypodermic use of vaccines, emetin, etc. Reliance must always be placed upon oral hygiene in both the prevention and treatment of pyorrhea alveolaris.

CHAPTER VIII.

DENTAL CARIES.

By EDWARD C. KIRK, Sc.D., D.D.S., LL.D.

Dental caries, or as it is commonly designated, tooth decay, is a disease which, in so far as humanity is concerned, is practically universal in its distribution. It affects all civilized peoples, some uncivilized tribes and, under certain conditions, even some of the lower animals. No disorder that afflicts the human race is more common, as it has been shown by abundant statistics that from 85 to 95 per cent. of civilized human beings are more or less the victims of dental caries or have suffered from its ravages at some period of their lives. Dental caries is essentially a disease of childhood and adolescence, the developing individual appears to be peculiarly susceptible to its invasion, whereas when adult life is reached the tendency to tooth decay is noticeably lessened as in the majority of cases when the individual has reached full maturity the progress of tooth decay appears to be markedly arrested. So manifest are these differences in the activity of dental caries as related to the age and development of the individual that the phenomena of susceptibility and immunity to the disorder are accepted as characteristic of its activity. As further evidence of the same characteristic a small proportion of individuals are found to be quite free from any evidences of tooth decay, never having suffered from its invasion at any time or in any degree, these are regarded as being naturally immune.

The period of childhood and adolescence being the period of greatest susceptibility to dental caries makes its relationship to the health of children of school age one of vital importance, not only from the hygienic point of view but upon educational and economic grounds as well.

Comparatively recent studies of the question furnish abundant evidence of the fact that the prevalence of dental caries among children of school age is the fruitful primary cause of mental backwardness, interrupted brain development, nervous disorders, errors of vision and of hearing, bodily malnutrition and a host of evils which not only retard or interfere with the educational process but impair to a serious degree the physical and mental efficiency of these developing citizens of the future generation. Hence the importance of not only a proper understanding of the nature of this important disorder but a clear appreciation of its gravity as a menace to human health and efficiency.

For purposes of anatomical description a tooth is viewed as having a crown (corona) which is all that part of the tooth exposed beyond the gum, and a root (radix) or radicular portion which is all that part of the tooth embedded in the bony socket or alveolus beneath the gum. The portion at the gum line between the crown and the root is designated as the neck (cervix) of the tooth.

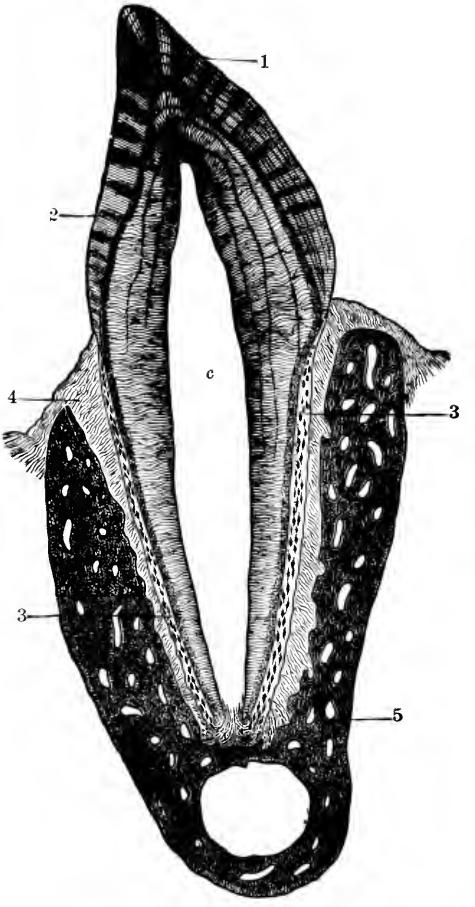


FIG. 103.—Vertical section of a tooth *in situ* (15 diameters). *c* is placed in the pulp cavity, opposite the cervix or neck of the tooth; the part above is the crown, that below is the root (fang); *1*, enamel with radial and concentric markings; *2*, dentin with tubules and incermental lines; *3*, cementum, or crusta petrosa, with bone corpuscles; *4*, pericemental membrane; *5*, bone of mandible.

Dental caries is a destructive process affecting the hard dental tissues; these are three in number: (1) The enamel which is the hard outer protective covering of the underlying dentin of the tooth crown and (2) the cementum or crusta petrosa covering the dentin

of the root; and (3) the dentin which forms the principal body of the tooth. Within the body of the dentin in the central cavity of the tooth is located the tooth pulp, a soft, highly sensitive and vascular organ, commonly but incorrectly called the "nerve." From a group of specialized cells upon the surface of the dental pulp there radiate through the dentin innumerable fibers of living matter, richly endowed with sensation, which with their lateral processes ramify throughout the dentin structure. These are termed the dentinal fibers or fibrillæ, and it is through their agency that we perceive the painful impressions arising from irritation of the dentin by cutting, by heat, cold, sweets, etc.

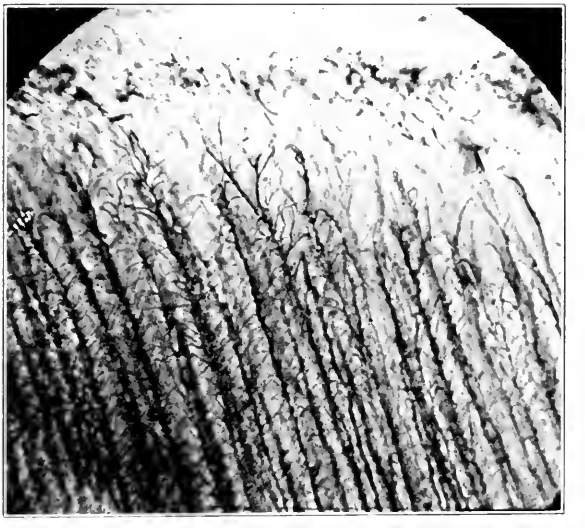


FIG. 104.—Longitudinal section of dentin, showing distribution of dentinal fibers and stratum granulosum. (Miller.)

Dental caries always has its inception upon the external or exposed surface of a tooth; it never arises from within the tooth. For a long period it was held by many students of the subject that tooth decay was an inflammatory process similar in certain respects to necrosis of bone, and those who accepted that view also held that caries originated within the tooth structure and gradually progressed outwardly toward the free enamel surface. This theory was maintained by some until quite recent times, but its fallaciousness was finally completely demonstrated by the researches of the late Prof. Dr. W. D. Miller, published about 1880, which finally gave to the world the true explanation of the process of tooth decay.

Briefly stated, Miller, as the result of a long and exhaustive experimental study of the subject, found that the destruction of the hard structures of the tooth by dental caries was accomplished through

the agency of a certain class of microörganisms which had the characteristic function of fermenting certain of the sugars and converting these sugars into lactic acid, which acid in its turn attacked the solid structure wherever it came into contact with it, dissolving out its mineral matter which caused the structure to disintegrate, forming a cavity which gradually enlarged until it eventually included the entire crown; indeed, if unchecked, the whole tooth may in this manner become disintegrated and lost.

A tooth, however, is not wholly composed of mineral matter soluble in lactic acid. If we immerse a tooth for a sufficient length of time in an acid, for example, dilute nitric or hydrochloric acid, it will be found to have lost all of its enamel covering and the remaining dentin and cement structures while still possessing the general conformation of the original tooth will be found to have lost their hardness to such a degree that the structure may then be easily cut with a knife into chips or slices like a piece of cartilage which the structure now closely resembles. We say of a tooth so treated that it has been decalcified, that is to say, the calcium or lime salts which gave to the tooth structure its characteristic hardness have been removed or dissolved out by the acid and what remains is an organic substance or animal tissue called the organic matrix or basis substance of the dentin and cementum.

The relative proportions of calcium salts or mineral matter and organic matrix or tooth cartilage in the dentin and enamel structures are shown in the following analyses:

DENTIN (Von Bibra).

Tooth cartilage	27.61	Organic matter
Fat	0.40	Organic matter
Calcium phosphate and fluoride	66.72	Inorganic matter
Calcium carbonate	3.36	Inorganic matter
Magnesium phosphate	1.18	Inorganic matter
Other salts	0.83	Inorganic matter

ENAMEL (Von Bibra).

Cartilage	3.39	Organic matter
Fat	0.20	Organic matter
Calcium phosphate and fluoride	89.82	Inorganic matter
Calcium carbonate	4 37	Inorganic matter
Magnesium phosphate	1.34	Inorganic matter
Other salts	0.20	Inorganic matter

ENAMEL (Kuehn).		DENTIN (Kuehn).	
CaO	53.75	CaO	53.42
MgO	0.84	MgO	2.41
P_2O_5	37.21	P_2O_5	39.46
Fl	0.29	Fl	0.25
Organic matter and H_2O	8.48	Organic matter and H_2O	32.10

Miller showed that the first phase of the carious process was a dissolving out of the mineral substances or decalcification of the tooth structure by lactic acid produced by the ferment action of certain microörganisms on sugars. He further showed that when decalcifica-

tion had taken place, infection of the exposed organic matrix of the tooth structure by a different type or class of microörganisms occurred, these latter known as proteolytic bacteria, had the power to liquefy and bring about putrefaction of the organic matrix and to destroy it in the same manner that a dead animal body is destroyed and disintegrated by putrefactive changes. These two phases of the carious process are essentially the same in principle, dependent upon the vital activities of microörganisms of two distinct groups, each having the power to decompose certain compounds which enter into the formation of tooth structure and to produce by their action certain characteristic physical phenomena and certain end or decomposition products equally characteristic. Thus in a cavity of decay the presence of acid may be easily demonstrated by bringing into contact with the decaying mass a strip of blue litmus paper which will at once turn red where the decaying mass touches it. The characteristic odor of putrefaction is readily recognizable, indeed, offensively so, in the breath of those suffering actively from tooth decay. This odor of putrefaction arises in large part from the decomposition of the organic matter of the dentin matrix through the agency of the proteolytic bacteria.

The human mouth is not only the portal of entry for many disease-producing microörganisms, but because many of these microscopic vegetable organisms thrive, flourish and rapidly reproduce themselves under the conditions of moisture, temperature and food supply that they find in the mouth cavity many species continue to inhabit the mouth and those which are possessed of disease-producing characteristics become the agency of infection by which a variety of bodily diseases are produced. An unclean mouth is therefore a constant menace to bodily health as well as the ordinary source of tooth decay. Fig. 105 shows a mixed infection of various bacteria from a tooth surface.

But though a great variety and an almost infinite number of microorganisms are constant inhabitants of the mouth, and though the lactic-acid-producing bacteria which cause tooth decay are found in nearly all human mouths, it is well known that many teeth do not decay, and even where the decay process is active not all surfaces of the teeth are equally vulnerable to the process of decay.

It has long been noticed that certain locations or areas upon the tooth surfaces are more liable to be the seat of decay than are certain other surface areas. In general, it may be said that those surfaces of the teeth that are subjected to the cleansing action of friction by the tongue, the lining mucous membrane of the lips and cheek surfaces or teeth surfaces which are kept free of bacterial invasion by the friction of rough or fibrous food materials, are less liable to decay; whereas, those surfaces of the teeth not subject to the self-cleansing action of the foregoing causes are most likely to be the seat of decay, as shown in Fig. 106.

Locations where food particles infected by mouth bacteria can find an undisturbed lodgement, such as the natural pits and depressions in

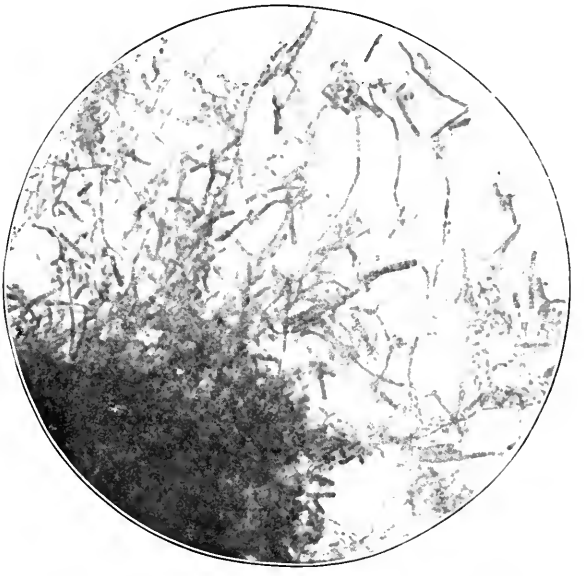


FIG. 105.—Mixed infection from tooth surface. (Williams.)

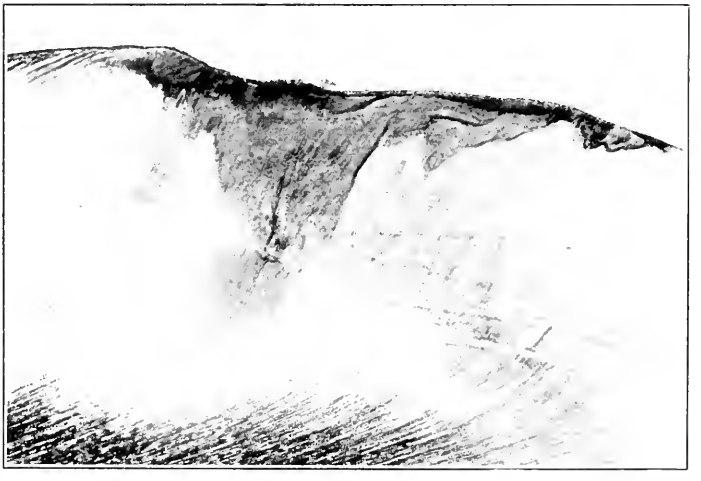


FIG. 106.—Caries localized above the "contact point" on the approximating surfaces of contiguous molar teeth. (Williams.)

the masticating surfaces of the molars and premolars, the sulci between the cusps, and especially the approximating surfaces of the teeth which by their mutual relations of contact afford protected areas for the

lodgement of food particles and its undisturbed decomposition by lactic-acid-producing bacteria are areas which in a susceptible individual are the selected locations of the carious process (Figs. 107 and 108).

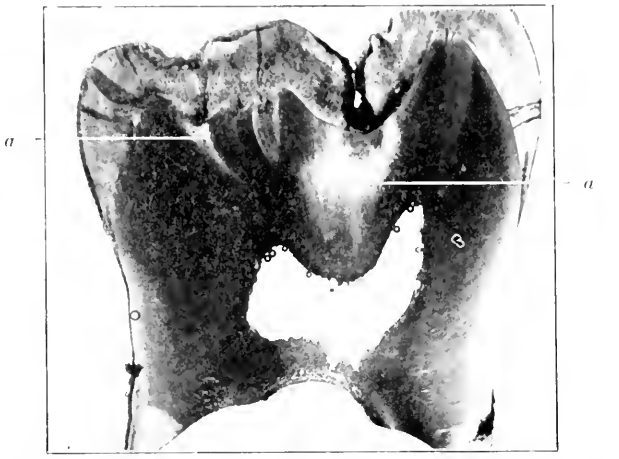


FIG. 107.—Beginning caries in sulci and enamel defects of morsal surface of a molar, also showing transparent zone of Tomes. (Miller.)

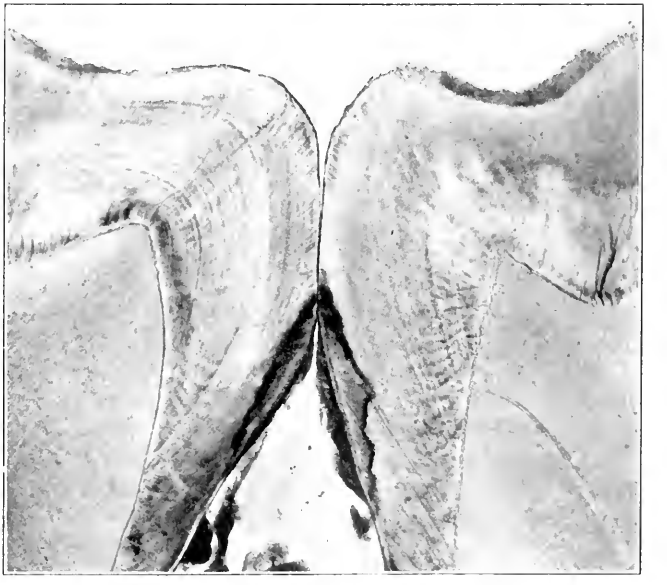


FIG. 108.—Beginning caries on approximal surface. (Miller.)

The determination of the location of tooth decay is in large degree a result of the form of the individual tooth and of the relations of the teeth to each other in the dental arches.

The structure of the tooth itself, that is to say, whether it be hard and dense or whether it be relatively soft and imperfectly calcified, does not in the slightest degree influence the liability of teeth to decay or otherwise. Any tooth will decay in a mouth where the conditions causing decay are active and no tooth will decay whatever its structure may be in a mouth where the conditions causing decay are not active. Or, as stated by the late Prof. G. V. Black, "decay of the teeth is a factor of the environment of the teeth. It is not due to the structure of the teeth in so far as their structure is characterized by density, hardness, softness, etc. These factors may influence the rate of decay but they do not determine the liability to decay."

When starchy food particles, sugars or any form of fermentable carbohydrate food material is lodged in contact with a protected area of tooth surface it becomes subject to the action of lactic-acid-producing microörganisms and undergoes fermentation resulting in its decomposition with the production of lactic acid. A familiar example of this process is the souring of milk when left exposed for a time to the air at a warm room temperature. Milk contains a considerable quantity of a characteristic sugar called sugar of milk and chemically designated lactose, having the formula $C_6H_{12}O_6$. Bacteria from the air fall into the milk and set up a fermentation of the milk sugar decomposing it or splitting it into lactic acid which when it accumulates sufficiently, gives the milk an acid reaction and a sour taste. The acid thus formed breaks up the combination of the casein with the base with which it was in chemical union and precipitates the casein as a curd so that the milk becomes thickened and when separated from its watery whey, this curd is the material from which cheese is made.

The casein or cheesy portion of the milk will also undergo putrefactive changes through the agency of proteolytic and other forms of bacteria which have the property of decomposing this type of organic matter so that the process of fermentation and subsequent putrefaction of milk is, in principle at least, quite analogous to the process of tooth decay.

The conversion of sugar into lactic acid by the fermentative agency of bacteria is represented by a chemical formula as follows:

$$\underset{\text{Glucose.}}{C_6H_{12}O_6} + \text{the enzyme of B. acidi lactici} = \underset{\text{Lactic acid.}}{2C_3H_6O_3}$$

that is to say, a molecule of the monosaccharid glucose is, under the action of the enzyme of the B. acidi lactici, split up into two molecules of lactic acid. Starches, cane sugar and the more complex carbohydrates must first undergo changes in the mouth into the simpler forms like glucose before they can be split into lactic acid and these preliminary changes are brought about by other enzymes, and particularly by ptyalin, the characteristic ferment of the saliva which possesses marked amylolytic properties or the power to convert starches into sugars that may be subsequently split into lactic acid by the agency of the proper bacterial enzyme.

These chemical alterations as the result of the action of digestive ferments and bacterial enzymes upon the debris of food substances are constantly going on in mouths which are not kept clean and free from food remnants either by habitual use of the usual tooth-cleansing devices of brush and dentifices, unless we may exclude those exceptional cases which are naturally self-cleansing and therefore immune. It is this constant fermentative activity that initiates dental caries wherever on a localized area of tooth structure it is permitted to continue undisturbed.

It should be borne in mind that dental caries is a distinctly localized process in its inception. The disease may appear in one or many places in the same mouth, at the same time, but it is localized in the sense that it does not attack all surfaces of the teeth simultaneously, nor with equal impartiality. Many who in the beginning of their study of the pathology of dental caries have clearly grasped the fact that lactic acid is the agent which initiates the disorder by dissolving out the lime salts of a localized area of tooth structure, and that the first stage of cavity formation is thus explained, not infrequently jump to the erroneous conclusion that lactic acid alone is the cause of tooth decay and cavity formation.

As a matter of fact, a generally acid saliva, even if the acidity be due to lactic acid, will not give rise to tooth decay. An acid saliva is destructive of tooth structure by bringing about a general decalcification of the teeth which is manifested more intensely in certain locations than in others, but this type of destruction of tooth structure is not dental caries but what is called chemical erosion of the teeth, a disorder not necessarily dependent upon bacterial activity, as it may be produced by any free acid formed in the mouth, exuded into the mouth, or taken into the mouth.

Dental caries is a characteristic disease with a well-marked and definite group of symptoms and within certain limits it has a known causation, which is the localized destruction of the hard tissues of the tooth by the solvent action of lactic acid generated at the point of decay by the agency of bacteria acting upon carbohydrate foodstuff.

While localization of the decay process is to a large degree determined by the forms of the teeth and their relations to each other, as already explained, there is another and somewhat complicated method by which fixation of lactic-acid-producing bacteria to a tooth surface is brought about, a method which because of its importance in relation to oral hygiene as well as to the causation of decay should be clearly understood and that is the localization of decay-producing bacteria upon the tooth surfaces by the precipitation of mucic acid from the mucin of the saliva by the lactic acid set free by the activity of the bacteria themselves.

The precipitation of the mucic acid upon tooth surfaces is discussed in detail in the chapter on Deposits Upon the Teeth, as it is a result of bacterial activity responsible to a considerable degree

for the formation of those adhesive deposits upon the teeth to which the general designation of tartar is applied; it is important to recapitulate its main features here in so far as they are concerned in localizing the process of dental caries.

In mouths where caries is in active progress the saliva is ordinarily rich in mucin which when present in appreciable quantities, is recognizable by the glairy or ropy, adhesive character of the fluid. The saliva has the property of viscosity; it has a certain cohesiveness and may be drawn out into threads of greater or less length according to the quantity of mucin that it holds in solution. Such saliva is nearly neutral or faintly alkaline in reaction. If to a small quantity of such a saliva gathered in a test-tube a drop of lactic acid, or, indeed, any acid is added, there will be formed at the point of contact an opalescent precipitate which is the mucic acid set free from the alkaline base with which it was previously in chemical combination in the saliva as mucin.

If the test-tube is allowed to stand undisturbed for some minutes the precipitate will settle to the bottom of the glass. The precipitated mucic acid is adhesive and insoluble except in an alkaline or saline solution. If now we apply these data to our study of what takes place in the mouth, we shall find that they throw much light upon the mode of localization of the carious process.

Assuming that in a susceptible mouth the saliva is rich in mucin held in solution by the alkaline salts of the saliva and that the mouth contains carbohydrate food material in the form of soluble sugars, produced by the amylolytic action of the salivary ferment ptyalin upon starchy food debris, then, in such a mouth infected by lactic-acid-producing bacteria, one or more of these organisms falling upon a tooth and temporarily lodged in some irregularity of the enamel surface, immediately sets up a fermentative action in the soluble sugar of its salivary environment setting free lactic acid in the immediate vicinity of the bacterium. The liberated acid at once decomposes the dissolved mucin of the saliva throwing down the adhesive mucic acid in contact with the body of the microörganism, cementing it, as it were, to its position upon the enamel surface. Multiplication of the bacteria proceeds rapidly and the process of acid production and mucic acid precipitation proceeds in harmony with the bacterial multiplication. The mass of bacteria thus organized and cemented to the tooth surface constitutes what is known as a bacterial plaque, the essential factor in the localization of tooth decay and the most important characteristic in the causation of the disease. (See Fig. 109.)

The bacterial plaque presents a variety of physical appearances under the microscope. It may exist as a small glistening semitransparent mass occupying only a small spot of the enamel surface or it may present the appearance of a film extending over a considerable area, in fact, over all surfaces of the tooth not subject to friction by food or the tongue and buccal mucous surfaces. The microörganisms

found in the plaque are never a pure culture of lactic-acid producers but while these are presumably always present, the organisms are usually those constituting the mixed infection usually found in the unclean mouth (Fig. 105).

It has been shown that tooth decay is brought about in the first place by the decalcifying action of lactic acid produced by the ferment action of bacteria upon carbohydrate food debris. This is, however, a general statement of fact that requires somewhat closer analysis in order that the exact nature of the process may be more clearly understood. All carbohydrate material is not directly fermentable into lactic acid, thus cane sugar and starches, two important nutritive substances, must undergo certain chemical changes in the mouth by which they are converted into simple forms of sugar, the mono-

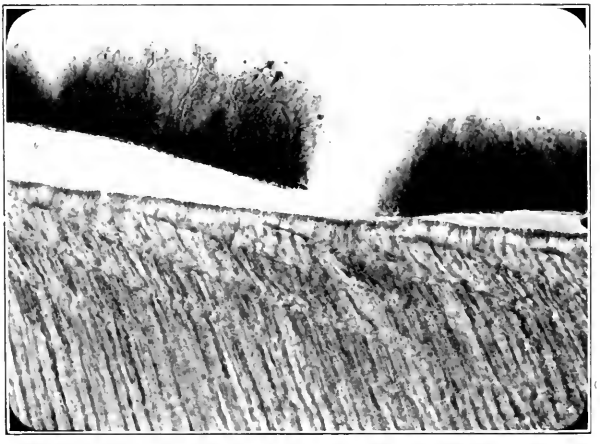


FIG. 109.—Bacterial plaque, detached from enamel surface of the tooth in making the preparation. (Williams.)

saccharids having the general formula $C_6H_{12}O_6$, before the bacteria of tooth decay can convert them into lactic acid, this preliminary change called hydration or hydrolysis, is brought about in the case of starches by the ferment ptyalin, an enzyme produced by the salivary glands and which is therefore a normal constituent of the saliva. Its function is to prepare the starches and possibly some of the more complex sugars for later assimilation by the cells of the body in the process of nutrition.

The physiological chemist Claude Bernard showed by experiment that cane sugar as such is not assimilated by the human organism when injected into the veins, but when taken into the mouth is later acted upon by a special amylolytic enzyme called invertase in the intestinal canal and thereby converted into a monosaccharid assimilable sugar suitable for the nutrient purposes of the organism.

The typical conversion of starch and of cane sugar respectively into lactic acid may be shown chemically as follows:

Cane sugar.
$$C_{12}H_{22}O_{11} + H_2O$$

becomes hydrolyzed through the action of invertase to

Glucose.
$$C_{12}H_{24}O_{12} = 2C_6H_{12}O_6$$

which through the enzyme action of B. acidi lactici is split into

Lactic acid.
$$4C_3H_6O_3$$

and

Starch.
$$C_{12}H_{20}O_{10} + 2H_2O$$

becomes hydrolyzed and starch through the action of diastase, or ptyalin, to

Glucose.
$$C_{12}H_{24}O_{12} = 2C_6H_{12}O_6$$

which through the enzyme action of B. lactici is likewise split into

Lactic acid
$$4C_3H_6O_3$$

From the foregoing it will be seen that the mother substance from which mouth bacteria produce lactic acid is a simple form of sugar belonging to the monosaccharid group of sugars called the hexoses from their chemical constitution, all having the formula $C_6H_{12}O_6$, a compound which readily splits into two molecules of lactic acid having the formula $2C_3H_6O_3$. The sugars being soluble substances readily diffuse into or are capable of absorption by the bacterial plaque so that the bacteria thus fixed and localized upon a protected tooth surface are nourished by a food supply of soluble sugar directly convertible into lactic acid which being produced continually in these localized areas of bacterial fixation exerts its solvent and decalcifying action upon the enamel without interference.

The manner in which enamel disintegrates under the solvent action of lactic acid is both interesting and important. The enamel covering of a tooth crown is made up of innumerable prismatic rods or prisms irregularly hexagonal in section and densely calcified. These enamel prisms stand endwise to the dentin and pursue a radiating and sometimes wavy course to the periphery or free enamel surface. The prisms are bound together by a material of much the same chemical nature as that constituting the prisms themselves, but it differs therefrom in the physical sense that it is more readily soluble in acids. If we take a thinly ground section of enamel and place it on a slide and while examining it under the microscope allow a drop or two of dilute acid to act upon the free edge of the specimen, we will see that the acid dissolves out the interprismatic cementing substance much more rapidly than it affects the structure of the prisms themselves; hence

the acid, because of this greater solubility of the interprismatic cementing substance, tends to penetrate between the prisms separating them from each other and causing them to fall apart as shown in Fig. 110.

It is precisely this effect that we see in the opaque chalky white spots that make their appearance upon susceptible tooth areas and which the intelligent operator recognizes as the beginning of dental decay. The opacity and chalky appearance of these spots is due to the fact that the interprismatic cementing substance that formerly gave the appearance of homogeneity to the enamel structure has been dissolved out leaving air or fluid in its place having a different refractive index than the enamel (Fig. 111). As the process proceeds the area enlarges and the enamel rods having lost the means of mutual support, fall apart and are lost, leaving an open cavity in their former location.

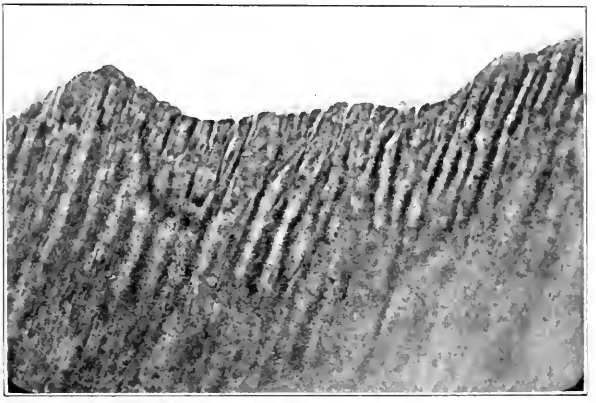


FIG. 110.—Section of enamel subjected to the action of dilute acid, showing solvent effect on the interprismatic cementing substance and penetration of the acid between the enamel rods. (Williams.)

The irritative effect of the gradual penetration of acid through the enamel in the process of tooth decay is manifest at a very early stage. Even before an actual cavity has been formed or the acid penetration has reached the junction of the enamel with the dentin, the latter tissue will have manifested its reaction to the irritation by recording certain characteristic changes in its structure. In a section of a tooth attacked by slowly advancing caries there will be noticed in the structure of the dentin lying subjacent to the line of invasion a cone-shaped area between the dentino-enamel border and the pulp cavity with the apex of the cone toward the pulp and the base toward the disintegrating enamel. This cone-shaped area of dentin is more transparent than the surrounding dentin structure and from its peculiar transparency has been called the transparent zone of Tomes, from Sir John Tomes, who first described it. Various theories as to the cause of this alteration in the character of the dentin structure have been

advanced, and such authorities as Tomes, Magitot, Miller and Walkhoff regard it as being an overcalcification of the dentin structure as a result of the irritation of the living matter of the dentin. Certain it is that it is the expression of a vital reaction upon the part of the dentin, for it does not occur in dead (*i. e.*, pulpless) teeth and it always does occur from long-continued slight irritation to the dentin from whatever cause. Its main importance in connection with the study of dental caries is that it records indisputably the fact that dental caries in its progress sets up irritation which is felt and recorded by the vital elements of the tooth, even in the earliest stages of the disease and before the integrity of the enamel surface has as yet been seriously disturbed (see Fig. 107, *a*).

CARIES OF DENTIN.

When the enamel has been penetrated and a cavity has thus been formed, invasion of the dentin rapidly follows. Caries of the dentin differs from caries of enamel in two important particulars arising out of the differences in structure and composition of the dentin as compared with that of the enamel.

The dentin contains a relatively larger amount of organic matter than the enamel; the earthy salts entering into the composition of the dentin are deposited in a cartilaginous substance having the general form of the tooth and known as the organic matrix or basis substance of the dentin. The organic matrix which in the formed tooth is fully calcified is everywhere permeated by fibrils of sensitive living matter encased in tubules which radiate from the surface of the pulp through the dentin structure. It is these fibrils of living matter that endow the dentin with sensation and which give rise to pain when the dentin is cut as in the preparation of a cavity of decay preparatory to the filling operation or when sweets, acids or other irritating substances are brought into contact with the walls of a carious cavity.

The distribution of living matter in the dentin may be seen from Fig. 104, which is reproduced from a photograph of a section of the dentin cut in the plane of the long axis of the tubules in which the fibrillæ run.

As soon as loss of enamel exposes the ends of the dentinal fibrillæ invasion of the tubules by the bacteria of decay promptly takes place and the tendency of the carious process is to follow the direction of the tubules toward the dental pulp.

Within the dentinal tubule the bacteria of decay elaborate their characteristic lactic acid which dissolves the sides of the tubule enlarging its diameter, the increased space being promptly packed with organisms reproduced from the parent pioneers of the invasion the dissolution of the tubular walls continuing until the area of decalcification involves adjacent tubules which have been undergoing a similar process of enlargement until coalescence of a number of tubes takes

place (Figs. 112 and 113). Coincidently, as decalcification proceeds and exposure of the organic matrix occurs, that structure is attacked by

FIG. 111.—Section of tooth, showing localized solution of interprismatic cement substance with enamel rods standing, constituting the "opaque spot" of beginning decay. (Miller.)

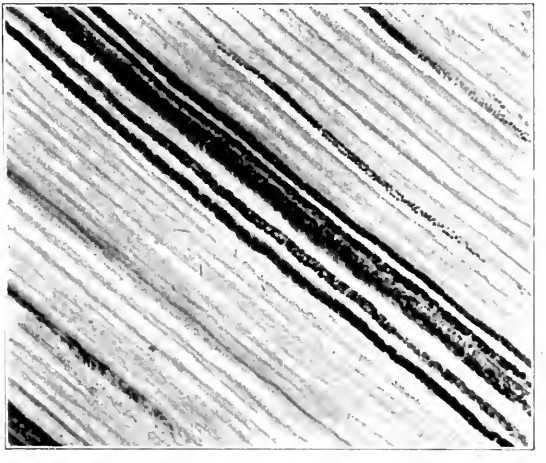


FIG. 112.—Longitudinal section of carious dentin, showing enlarged tubules packed with bacteria. (Miller.)

a group of bacteria known as proteolytic organisms which have the property of elaborating an enzyme that brings about liquefaction of

the cartilaginous proteid material constituting the organic matrix. Decomposition and putrefaction of the decalcified basis substance of

FIG. 113.—Cross-section of carious dentin, showing enlarged tubules. (Miller.)

FIG. 114.—Liquefaction foci in carious dentin. (Miller.)

the dentin thus takes place with the formation of so-called liquefaction foci in the dentin which liquefaction foci by their extension and coalescence ultimately produce what is commonly known as a cavity

of tooth decay, the process continuing until the pulp is reached or, if the process is not arrested, until the tooth is destroyed (Fig. 114).

It has already been noted that invasion of the dentin by the bacteria of caries is by way of the dentinal tubules which these organisms, generally speaking, follow toward the pulp and various considerations seem to indicate that this mode of invasion of the dentin is largely determined by the fact that the source of food upon which the organisms feed is found in the substance of the dentinal fibril or the juices of the fibril itself.

It has been clearly demonstrated by the researches of Miller, already referred to and confirmed by other able and trustworthy investigators, that dental caries can be, and is, due to decomposition of carbohydrate food particles in unclean mouths, from which we have drawn the conclusion that tooth decay is a filth disease, that if proper care as to oral hygiene is instituted and maintained dental caries may be eradicated; in short, we have come to regard it as an accepted fact that "clean teeth will not decay." This conclusion is probably too hastily drawn and without full consideration of all the factors involved, which tend to limit its general application.

Experience shows that teeth decay more rapidly in early than in adult life, that the teeth of some individuals decay more rapidly than others, that the teeth of some never decay, that many who give scrupulous attention to their teeth are extremely susceptible to decay of the teeth, while others whose mouths never receive any attention appear to be immune.

The problems of susceptibility and immunity to dental caries are as yet unsolved; there are, however, many indications that give color to the hypothesis that there are certain nutritional factors that have much to do with the susceptibility to dental caries or with immunity therefrom. Those who live upon an excessive carbohydrate diet are, as a rule, found to be more prone to carious invasion than those whose diet is largely of a proteid character. Probably under an excessive carbohydrate diet the percentage of sugar in the blood, normally about 0.001, is increased and if the salivary fluids and the juices of the dentinal fibrils derived from the blood reflect this increase in carbohydrate above the physiological normal would readily invite the invasion of decay-producing bacteria. In 1881 Milles and Underwood expressed the opinion that the bacteria feed upon the juices of the dentinal fibrillæ in dental caries as follows: "The organic fibrils upon which the organisms feed and in which they multiply are the scene of the manufacture of their characteristic acids, which in turn decalcify the matrix and discolor the whole mass."[1]

If, then, susceptibility to tooth decay is in considerable degree dependent upon a constitutional predisposition, oral hygiene alone and unaided cannot wholly prevent it, although it can undoubtedly greatly

[1] Trans. Seventh International Congress of Medicine, London, 1881.

diminish its ravages. It is highly probable from our present knowledge of the subject that complete control of this universal disorder can never be attained by local measures alone. The fundamentally important question of dietetics, of food habit, must be studied for what light it can throw on the solution of the problem, for even now the evidence is almost overwhelming that the inordinate and increasing habitual use of sweets by civilized children is a custom pernicious alike to the integrity of their dentures and to their general health.

Until the deeper underlying factors of the causation of dental caries are discovered we must rely upon the means at our command in the principles and art of oral hygiene to protect humanity as best we may from the scourge of dental caries and its consequent damage to health and life.

CHAPTER IX.

ODONTALGIA AND NEURALGIA.

By ARTHUR HOPEWELL-SMITH, Sc.D., L.R.C.P., M.R.C.S., L.D.S.

Introductory.—The word odontalgia is a pure Greek derivative, meaning literally "tooth pain." It is popularly spoken of as "toothache." But the latter term possesses another and more significant meaning which the popular imagination and experience cannot distinguish from pain in a tooth; it includes also neuralgia, the English form of two Greek words which indicate "nerve pain." It thus happens that odontalgia and neuralgia are frequently mistaken for each other. Further, it frequently happens clinically, that both occur simultaneously, thus rendering the pathological conditions which induce them obscure and difficult to determine.

It is the purpose of this chapter to set forth in a simple fashion an account of the two chief types of pain associated with the dental organs of man.

ODONTALGIA.

Odontalgia is not a disease, but a symptom or sign of a disease or diseases. Neuralgia, similarly, except for the very specific condition called epileptiform neuralgia, is a symptom. Pain itself cannot be a morbid state of the body. It is an indicator—a beneficent indicator of a diseased condition of an organ, due to a disturbance of the sensory nervous mechanism of that organ. A tissue or organ devoid of sensory nerves is incapable of feeling pain locally, as exemplified, for instance, in the liver. On the other hand, an organ freely supplied with sense filaments is exceedingly subject to pain, as exemplified in the dental pulp where the nerve fibers are partly sensory and partly sympathetic —that is, distributed to and thus control the blood vascular system.

It therefore follows that odontalgia is a common, special, important, and distressing symptom of certain diseases of the dental pulp; while neuralgia, generally associated with morbid affections of the nerves which are distributed to the teeth, may and does occur in connection with any sensory nerve of any part of the body remote from or near to the head and neck.

Definitions.—The two words odontalgia and neuralgia may thus be defined: odontalgia is pain in or around a tooth or teeth; neuralgia is pain in the course or the peripheral distribution of a sensory nerve or nerves.

For the proper comprehension of the meaning of the word "pain" it is necessary to define and note the causes and laws of sensations.

"Pain" can shortly be translated "a disagreeable sensation." It is not easily described, but for present purposes this definition will suffice.

Definition of Sensation.—A sensation is a means by which a person is made aware of the events occurring in the outside world—the means by which his environment acts upon him. It is the "consciousness of an impression made upon the mind through the medium of a nerve or one of the organs of sense." (Starling.)

Causes of Sensations.—Sensations are caused by some movement of molecules or masses occurring in the outside world which act upon the sense organs and convert them into nerve impulses which are carried either to the brain or spinal cord. In the case of the former, impulses give rise to some kind of so-called reflex action which may be either conscious or unconscious. If it is conscious, the person becomes aware of a sensation.

The five senses—touch, taste, smell, sight and hearing—do not complete the number of different sensations experienced by the human body. There are really eight, all told, for to the list can be added the sensations of temperature changes (heat, cold and their variations), the muscular sense, and, finally, pain.

Laws Governing Sensations.—All sensations are governed by two laws: First, the law of specific irritability, which states that every sensory nerve reacts only to one form of stimulus and gives rise to one form of sensation. In other words, every sensory nerve minds its own business. The second law—the law of proportionality—establishes the fact: "The increase of stimulus which is required to produce distinct increase of sensation always bears the same ratio to the whole stimulus." With regard to the muscular sense the proportion is one in forty, in the tactile or pressure sense one in thirty.

Pain a Distinct Sense.—Pain is, as has already been observed, an uneasy or disagreeable sensation, due to overexcitation or undue stimulation of a sensory nerve, no matter what the nature of the stimulus. Thus, if the elbow be placed in a dish of iced water the trunk of the ulnar nerve is stimulated, and pain is referred to the third and fourth fingers by virtue of their muscles being supplied by the superficial palmar branch of this nerve. If the so-called "crazy-bone" sustains a blow sensations are conducted also to the same digits.

Pain is a distinct sense. It is not an exaggerated tactile or temperature sensation, but promoted by a distinct set of special nerve fibers, although indistinguishable under the microscope from motor, sensory or sympathetic nerves. It is a well known clinical fact that many patients are insensitive to pain, yet they are able to respond immediately to touch. Many patients in whom the tactile sense is deficient or absent, suffer from an exaltation of the pain sense. Further, certain areas of the skin afford examples of the existence of pain "spots" which are similar to the "heat and cold spots" found, for instance, on the palm of the hand.

In certain regions of the body only one sensation is experienced, by whatever means induced. The cornea is capable of feeling only painful sensations; all kinds of stimulation are converted into the one sensation. The presence of foreign substances on its surface, such as a piece of grit, a stray eyelash, a chemical irritant, induces pain.

And it is thus with the teeth.

In normal circumstances teeth do not feel anything. When they are occluded in the ordinary way no impression is recognized by the brain; but when they are brought into contact by a *conscious act*, the tactile or pressure sense is established and the brain becomes aware of what has taken place. The act of placing a finger on the surface of a tooth sets up weak tactile sensations, and the brain takes cognizance of the fact because it is done consciously. The same argument applies to the exercise of walking, where, ordinarily, tactile impressions on the soles of the feet are not felt unless the act is being accomplished consciously.

It is therefore obvious that as the dental pulp and the periodontal membrane are abundantly supplied with sensory nerves, and are from this viewpoint special sense organs, unable to differentiate between the several kinds of stimulations, these two tissues, like the cornea, are incapable of interpreting the various kinds of stimulations in any other term than the one of pain. Irritation of the dental tissues, whether it be set up by heat, cold, sweet, sour, bitter or acid substances, electrical, mechanical or bacteriological disturbances, is translated by the dental pulp and periodontal membrane into pain.

Anatomical and Physiological Considerations.—The exact method of conduction of impulses from outside sources to the pulp is still a matter of controversy. The limits of this article do not allow of a discussion of the subject; but it may be stated generally that the enamel of the teeth, being merely an inorganic substance—a secretion which has undergone calcification, transmits and does not generate sensations. It conducts any of the above mentioned stimulations to the dentine beneath. The latter tissue, probably by irritation of the dentinal fibrils, contained in its manifold canals, in its turn transmits impulses to the pulp, and the brain responds through the direct paths of the nervous mechanism of the latter.

The reaction time in man differs according to the physical condition of the subject of the experiment, the length of the so-called "dilemma," and other circumstances, but may be considered as varying from 0.15 to 0.2 second. Generally speaking, it may be said that it is quicker than an ordinary electrical current.

Varieties of Pain.—Pain varies in character and type. It may be (1) direct or local; (2) indirect or reflex.

1. The direct form occurs after a local injury, *e. g.*, extraction of a tooth at the place in the mouth where removal of the tooth has been effected.

2. The indirect form occurs at a distance from the injury or disease,

e. g., some functional disturbances or pathological conditions of the liver set up pain under the left scapula, others in the epigastrium. Some form of reflex action in another organ or organs may be referred to the teeth; thus, the phenomenon commonly called "setting the teeth on edge" may be produced by reflex sensations from the nerves of hearing, touch or sight. A friend of the writer once told him that his teeth had been set on edge, when in India, by observing children in certain parts of the country sucking sugar cane. Contact with the velvety surface of the skin of a peach, the creaking of a wheel, may also be cited.

Pain varies in type. It may be sharp or dull, agonizing, lancinating, aching, continuous, intermittent, localized or diffuse. The nature depends on the cause and on the anatomical peculiarities of the tissue affected.

In making the diagnosis of the cause of pain great attention must be paid to the foregoing types. This is usually an easy matter, but at times extremely difficult on account of complications.

Causes of Odontalgia.—It has been indicated that the two dental tissues in which pain may originate are the pulp and the alveolo-dental periosteum.

Three **varieties** may be noted: (*a*) Local odontalgia; (*b*) referred odontalgia, and (*c*) obscure odontalgia.

(*a*) Local odontalgia is a symptom of (1) acute or chronic hyperemia and inflammation of the pulp, or (2) acute or chronic hyperemia and inflammation of the periodontal membrane; (*b*) referred odontalgia is a symptom of any condition which gives rise to irritation of the peripheral branches of the fifth pair of nerves and their connections; (*c*) obscure odontalgia occurs in teeth without any obvious visible lesion.

Local Odontalgia.—When a warm solution is taken into the mouth and induces slight odontalgia it indicates that the vessels of the pulp are congested. If the condition remains unrelieved inflammation follows.

Pain in acute pulpitis is symptomatic of the disease. Its intense character is due to the fact that as a result of the enlargement of the bloodvessels, the exudation of inflammatory cells and products, the inflammation of the nerves themselves, and the increase in the amount of perivascular material taking place in a soft, highly vascular tissue, incapable—owing to its enclosure in dense, unyielding walls of dentine—of expansion, great tension is brought to bear on the already inflamed sensory nerves distributed throughout.

The phenomenon is somewhat different in the case of the periodontal membrane. It is here modified to some extent by the swelling of the membrane consequent on the inflammatory changes going on within, being compensated by a slight elevation of the tooth in its alveolar socket.

In the early stages of acute periodontitis pressure on the offending

tooth brings immediate relief; for blood is pressed out of the enlarged vessels, which thus momentarily return to their normal diameter and capacity. In later stages, however, the walls of the bloodvessels do not regain their elasticity, nor the blood current its equilibrium. They remain, therefore, more or less permanently dilated; hence pressure increases instead of diminishes or abolishes pain.

It frequently happens that both pulp and periodontal membrane are affected. The types of pain above indicated then become complex and the diagnosis involved.

The following differences in types of pain in uncomplicated cases will be found useful:

DIFFERENTIAL DIAGNOSIS OF ACUTE INFLAMMATION OF:

THE DENTAL PULP.	THE PERIODONTAL MEMBRANE.
1. Pain: Sharp, shooting, intermittent, throbbing, reflected.	1. Dull, gnawing, aching, continuous, localized.
2. Temperature: (*a*) Cold may give relief in early stages; (*b*) heat intensifies pain.	2. (*a*) Cold generally gives relief; (*b*) heat does not alter character of pain.
3. Inspection: Tooth normal height.	3. Tooth raised in socket in later stages.
4. Palpation: Tooth firm.	4. Tooth loose in later stages.
5. Percussion: Negative.	5. Induces pain.
6. Pressure: Negative.	6. At first relieves pain; in later stages intensifies it.
7. Cavity: Generally present.	7. No cavity.
8. Pain: Increased on assuming recumbent position.	8. Not increased.

In view of the fact that odontalgia is the chief symptom of acute and chronic pulpitis and periodontitis and their complications, the causes of these conditions are identical with that symptom. They may be enumerated as follows:

(A) *Acute Pulpitis, Including Hyperemia.*—(1) The toxins of caries-producing organisms of dental caries; (2) injury to the dentine; (3) extension of inflammation from the periodontal membrane; (4) cold; (5) rheumatism and allied constitutional disorders; (6) abuse of mercury, taken internally; (7) fillings, inducing thermal conductions.

(B_1) *Acute Local Periodontitis, Including Hyperemia.*—I. *Septic conditions* set up by (i) extension from the septic pulp; (ii) dento-alveolar abscess arising in a neighboring tooth; (iii) "pyorrhea" pocket. II. *Traumatic disturbances* set up by (i) irritation produced by the presence of tartar, edge of badly-fitting crown or denture; (ii) malocclusion; (iii) improper application of rubber dam clamp; (iv) blow on a tooth; (v) too rapid separation of teeth before filling a cavity; (vi) too rapid movement during regulation; (vii) perforation of dentine of root through the side; (viii) passage of instruments through the apex; and (ix) occasionally, passage of root filling through the apex; III. *Chemical causes* set up by the use of various drugs.

(B_2) *Chronic Local Periodontitis* induced by: (i) *Septic infection* from root canal; (ii) *Traumatism*, such as a blow on a tooth, edge of

tartar, rough edge of filling, carious cavity at gingival margin retaining food *débris*, malocclusion, imperfectly contoured filling, and delayed eruption of teeth.

(B[3]) *General Periodontitis* due to gout, diabetes, rheumatism, syphilitic stomatitis, abuse of mercury, insufficiency of mastication, etc.

Referred Odontalgia.—The commonest form of referred odontalgia is expressed in the pulp of a tooth which is not in itself the seat of the pain. A maxillary molar may refer its pain to the mandibular molar on the same side; a mandibular third molar may refer its pain to a mandibular premolar. Pressure on the supra-orbital branch of the frontal division of the ophthalmic nerve as it emerges from the supra-orbital foramen may induce odontalgia in the maxillary canine of the same side. The pain never crosses the mid-line of the face.

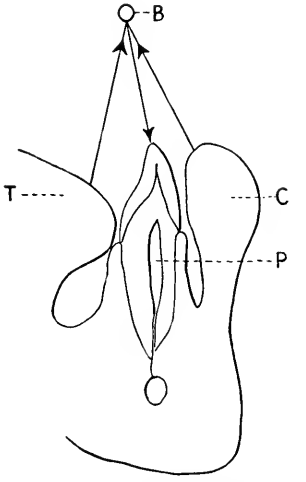


FIG. 115.—Diagram of a reflex act. The sensory nerves in (*T*) the tongue and (*C*) cheek send stimuli to (*B*) the brain, which transmits them to (*P*) the dental pulp. Thus exceedingly sweet substances on the tongue will, at times produce odontalgia.

Obscure Odontalgia.—Odontalgia may occur in teeth unaffected by dental caries. It is then due to one of the following causes: (1) Increased or diminished blood-pressure in the pulp; (2) pulp nodules; (3) altered chemical constituents of the blood; (4) intra-oral electrical impulses; (5) reflex from tongue; (6) lesions of Vth nerve; (7) general neurasthenia and debility.

The physiological and pathological conditions during which obscure odontalgia may arise as a symptom are associated with: (1) The period of puberty in boys and girls, and during the plethoric habit in men, in menstruation or menopause in women; (2) rheumatism and allied blood diseases; (3) lack or deficiency of lime salts in the blood; (4) slight impulses producing weak voltaic currents generated during operations about the mouth, as the contact of dissimilar metals when the saliva

happens to be sufficiently ionized (Fig. 116); (5) on taking very sweet substances into the mouth under certain emotional or nervous circumstances (Fig. 115); (6) inflammation, injury, tumors, and (7) periods of mental depression following overanxiety or overwork.

In all of these there is no visible pathological lesion of the teeth, excepting under (4), where carious cavities have been filled with gold or amalgam and occupy a large area of the tooth surface.

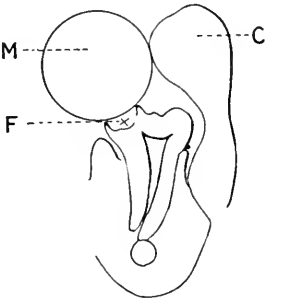


FIG. 116.—Diagram of a reflex act. An electrical impulse may set up momentary odontalgia when two dissimilar metals, such as those of the edge of a hand mirror (*M*) and (*F*) of metallic filling, meet, and the circuit is completed by (*C*) the mucous membrane of the cheek, the saliva acting as the electrolyte.

NEURALGIA.

Definition.—Neuralgia is pain in the course of a sensory nerve, or within its area of distribution.

Neuralgia is an extremely general symptom of some of the phases of many nervous disturbances occurring in any part of the body. Commonest when affecting the head and neck, and associated chiefly with the trigeminal nerve, this symptom of disease may become the most terrible affliction to which man is subject. It may be regarded as a serious sign, for the accumulated results of long-continued pain may lead to severe mental and constitutional conditions which are very difficult to treat successfully.

Nature and Type.—The character of the pain varies considerably. It is, however, well differentiated from odontalgia. Thus, it may be sudden and violent with decided remissions and intermissions; it may be recurrent, alternating and periodic; it may be shooting, piercing and penetrating. It generally commences quite suddenly, spasmodically, and without warning, and increases gradually to a climax of intense exacerbation, then slowly or rapidly subsides. The attacks may last for minutes, or hours, or days. The writer recalls a case where the most agonizing pain lasted for fifteen minutes at a time, then passed away for a short period, only to return again with increased vehemence. Slight exciting causes may induce neuralgia, such as a sudden noise, like the banging of a door, a draft of air. Pressure on the trunk of the affected nerve may occasion, or relieve, or intensify

the pain. The parts in the neighborhood of the nerve may become affected; muscles may become spasmodically contracted; the skin hyperemic and swollen, and the secretions from the sweat-glands excessive in amount. Skin eruptions, such as herpes of the lip may occur, and the temporomandibular joint become tender, and a kind of trismus produced.

Causes.—The general and local constitutional disorders of which neuralgia is a symptom may be difficult to determine. Among them hysteria, mental depression, migraine, neurasthenia, general debility, malaria, anemia, influenza, difficult dentition and unerupted teeth in children, may be suspected; while tumors of the brain, injuries to nerve trunks, various forms of neuritis, and tumors of the nerves may also be enumerated.

Edentulous persons, in whom much atrophy of the alveolar processes of the jaws has occurred as a result of premature loss of the teeth, frequently experience neuralgia through pressure set up by wearing a denture. In this way the mandibular nerve, though unexposed in the mandibular canal, is often affected.

Varieties.—Four true types of neuralgia have been described: (1) *Neuralgia Quinti Major*—the *tic douloureux* of some authors; (2) *Neuralgia Quinti Minor;* (3) neuralgia secondary to disease of, or injury to, or pressure upon a cranial nerve, as a tumor of the trunk of the trigeminal, and (4) neuralgia secondary to general disease such as anemia, etc.

Neuralgia Quinti Major may begin either in the Gasserian ganglion or in the peripheral distribution arising, as Sir Victor Horsley first described, from an ascending neuritis due to chronic osteitis of the sockets of the teeth.

Neuralgia Quinti Minor is a visceral referred pain due to chronic pulpitis, chronic periodontitis and their complications. It may be explained thus: "When impulses pass up sensory nerves from a tooth which is diseased, they set up a disturbance in that segment of the nervous system to which they are conducted. Any second sensory impulse from another part, *e. g.*, from the surface of the face, which happens to pass into that segment will be profoundly altered in character, for it no longer falls into a normal but into an actively disturbed segment of the nervous system. The resulting stimulus therefore becomes more exaggerated in character."

On the face these areas represent the segmental origin of the nerves that give rise to heat, cold and pain.

This part of the subject has been thoroughly investigated by Valleix and Prof. Henry Head, who has mapped out on the skin certain well-defined regions which are under the influence of the individual teeth.

The accompanying illustrations (Figs. 117 to 124) demonstrate graphically these areas, and need not be fully described. The reader is referred to the writer's "Dental Anatomy and Physiology," or the original article in *Brain*, Part III, 1894.

Bordering upon the line between physiological and pathological pain, if one may use such a term, is an unusual affection or disturbance,

FIG. 117.—The frontonasal area (maxillary incisors). In this and the succeeding figures, the "maximum spots" of intensity of pain are indicated by a round white dot.

FIG. 118.—The nasolabial area. (Maxillary canine and first premolar.)

FIG. 119.—The temporal area. (Maxillary second premolar.)

FIG. 120.—The maxillary area. (Maxillary second premolar or first molar).

not a disease, of the trigeminal nerve, similar perhaps in origin to a hemicrania when due to hyperemia of the vessels of the cerebrum.

Hughlings Jackson says one form is due to digestive derangements. Here changes in the feeding customs of an individual—digestive changes or altered constructive metabolism due to a newly acquired fasting or

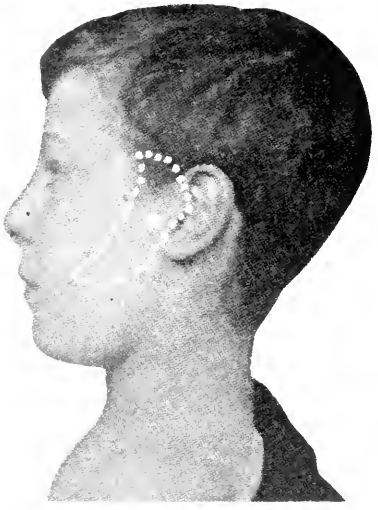


FIG. 121.—The mandibular area. (Maxillary second and third molars.)

FIG. 122. — The mental area. (Mandibular incisors, canine and first premolar.)

FIG. 123.—The hyoid area. (Mandibular second premolar, and first and second molars.)

FIG. 124.—The superior laryngeal area. (Mandibular third molar.)

semi-fasting habit—may and do often set up odontalgia and neuralgia, very difficult of diagnosis by dentist and physician. Located and limited to one side of the face, it is always the same side or alternate sides of the face which are affected, as if one of the pairs of the Vth nerve was more susceptible for some reason to these changes, and as if the brain was content in indicating the presence of a deep-seated disturbance only by one, and not by two routes. It spreads over a large area and does not involve the mastoid region or concha of the ear. It is increased on deep pressure outside of the jaw, over the root of the tongue.

The pain is heavy, dull, spontaneous, persistent, deeply planted, apparently in the body of the mandible, maxilla or cheek. The soft palate, tongue and tonsils are unaffected. It may last for a half hour or less and then disappear. No maximum spots of intensity are noticed. Digital pressure increases it; hot and cold objects have no effect, though cold may at times relieve it. Pressure as from a soft substance, like a cushion or pillow, produces an exacerbation.

The teeth are very sensitive. A cold finger gently passed over their crowns increases the pain; pressure and percussion do not. Occlusion of the opposing teeth does not.

Excluding migraine, the cause of the trouble appears to be anemia or metabolic disturbances of the sympathetic nervous system, due to slight temporary gastric disturbance set up by malnutrition or influenza.

A full, easily digested meal will usually relieve the pain, while the exhibition of drugs, such as acetophenetidin, in 5-grain doses, is also indicated. Tonics and general attention to health should also be advised.

Treatment.—Little need be here said about the therapeutic measures which are available for the relief of odontalgia and neuralgia, for it is obvious that the treatment of the symptom and not the cause of the symptom is unscientific and incorrect. Odontalgia can be, and is, treated with much success by a skilful dentist, but neuralgic conditions should be treated by common sense coöperation with the physician and surgeon. It is therefore the duty of the dentist to call in a medical man in consultation in cases needing his help for the relief, if not the cure of the disorders which have led to the production of the above distressing symptoms.

Conclusion.—It may be stated in general terms that if reasonably hot and cold foods and drinks can be taken into the mouth without inducing odontalgia or neuralgia the dental pulps of the teeth are in good condition; and that if no obvious cause for odontalgia is present, such as a carious cavity, such symptoms must be looked for elsewhere. Hyperemia of the pulp is indicated and may be diagnosed if pain is experienced at a localized situation on holding warm fluids in the mouth, especially if a breach of enamel or dentine is associated with it.

If this examination fails and the pain still persists, the tongue may next be suspected and thoroughly inspected and tested for nerve

reflexes; then general constitutional causes—vascular disturbances due to puberty, menstruation, pregnancy, the climacteric, etc., conjectured, and finally, degenerative conditions of the dental pulp may be diagnosed.

The prompt recognition of these latter changes will be convincing alike to patient and dentist, and the solution of some of the problems of odontalgia and neuralgia satisfactorily determined.

CHAPTER X.

THE RELATION OF ORAL INFECTIONS TO GENERAL HEALTH.

By KURT H. THOMA, D.M.D.

INFECTION in the jaws is not a modern disease. Centuries ago tooth abscesses were common among the Egyptians of the predynastic period, as well as of the Old and Middle Empires. In a study which the writer made at the Peabody Museum of a large number of Egyptian crania it was found that as far back as 4800 B.C. people suffered from alveolar abscesses. This was evident from the bone destruction seen around diseased teeth. The condition, however, arose then from a source different from its origin today. Instead of decay leading to the pulp infection, the primary cause was abrasion of the tooth surface,

FIG. 125

that is, wearing away of the tooth until the pulp became exposed (Fig. 125, *A*). This abnormal wear on the teeth was caused by the coarseness of the food, as well as by the grit present in their cornmeal after its preparation in stone mortars. The infection, which gained entrance in this way, proceeded through the opening in the root into the surrounding bone, as it does today (Fig. 126). In those days, however, the opening in the tooth was not sealed up by a root canal filling and so there was a permanent outlet for accumulating pus.

In our time oral infections are so common that there are very few people who have not at least one abscessed tooth. On account of the chronic character of most of these infections, patients as a rule are entirely unaware of their existence. The frequency of such lesions is

well brought out by Dr. Black of Chicago, in statistics which he compiled from roentgen pictures of all the teeth of 300 people. These examinations were not made because of any complaint, or indication of treatment and, therefore, they represent as near an average of such

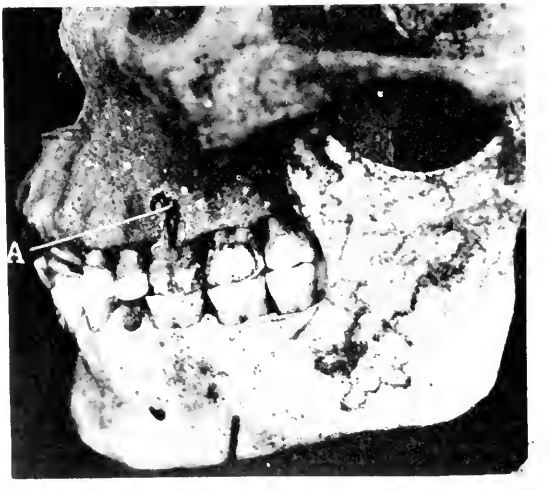


FIG. 126

conditions as can be obtained. The following tabulation gives the result:

Number of patients examined.	Age. Years.	Percentage of dental affections.
86	Under 25	56
53	25 to 29	72
68	30 to 39	87
53	40 to 49	89
40	Over 50	100

PERIAPICAL INFECTIONS.

The most important oral infections to be considered in connection with the general health are those affecting the periapical tissues. The infection nearly always enters through the root canal, but occasionally it finds its way to the inside of the jaws through a pus pocket along the side of the root of a tooth. Infection from the root canal may result either from an acute or chronic pulpitis caused by decay, from a necrotic pulp or an infected root canal which has not been properly sterilized and filled, or from root canal instrumentation. Fig. 127 shows a photomicrograph of a molar with a cavity from which bacteria penetrated into the pulp through the dentinal canals, forming a large abscess (*A*) in the pulp chamber. The nerves of the pulp have been pressed to one side and surround the abscess. Fig. 128 shows a roentgen picture of a tooth where the infection has started from a

pocket (*A*) on the mesial side of a molar. When the apex of the tooth was reached an abscess formed, which infected the pulp in this otherwise healthy tooth.

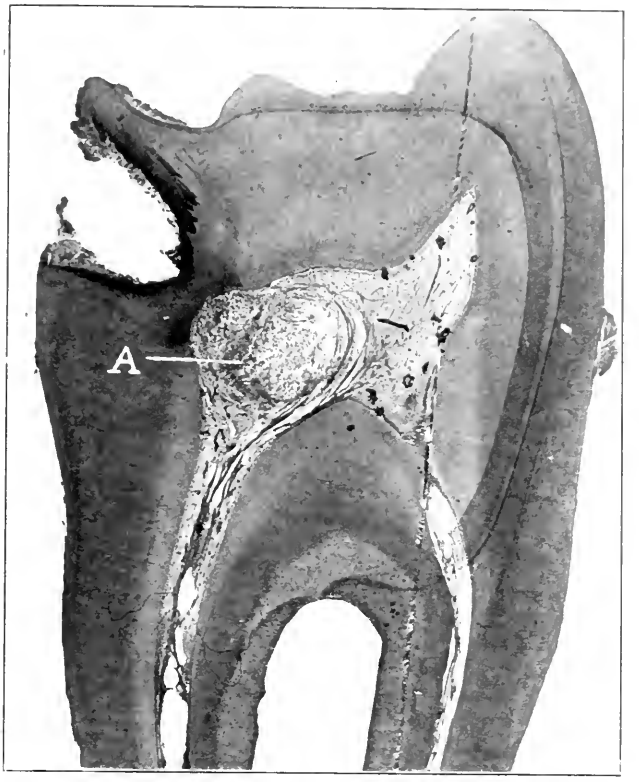


FIG. 127

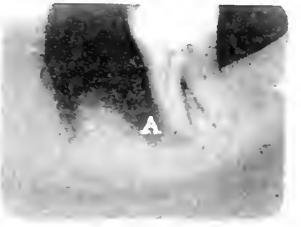


FIG. 128

Periapical infection may follow either of two distinct chains of pathological changes. The first is of a destructive nature and begins with a reaction causing all the symptoms of acute inflammation, while

the other from the beginning is characterized by a mild and chronic reaction, which starts and continues without giving any local symptoms.

Acute Periapical Infection.—This condition starts as acute periodontitis and involves a violent inflammatory reaction of the tissue. Purulent exudations soon accumulate, the cells of the peridental membrane and the surrounding bone become destroyed and the condition is then called an acute alveolar abscess. This may spread and cause suppurating ostitis of greater extent, or the pus may soon find an outlet to the surface *via* the Haversian canals, which penetrate the outer cortical layer of bone. When the pus collects under the periosteum, a reaction sets in at once, causing a widespread serous infiltration of the soft parts, the cheek or neck. Finally the pus burrows a channel through the soft tissue, forming a fistula into the mouth, nose, maxillary sinus, or outside of the face. After this process of destruction has reached its climax Nature makes an attempt at repair and the acute symptoms disappear, but unless the cause (a diseased pulp or necrosed root apex) is removed the condition becomes chronic. In this stage it may last for an indefinite period with the fistula discharging pus if the destructive process becomes more active, or closing up for a time if the defensive system predominates, only to reopen with more or less marked subacute symptoms when suppuration again becomes more active.

Blind Abscess or Dental Granuloma.—The difference between an acute alveolar abscess and a blind abscess, or dental granuloma, should be clearly understood. The former is a suppurative inflammation and involves a process of destruction of the peridental tissues, dissolving them into pus. The latter is a reaction to a mild infection, stimulating inflammatory new growth and active suppuration does not occur at first, but an exacerbation may change the pathological picture later so as to simulate a typical acute alveolar abscess. The blind abscess, or granuloma, begins and continues to grow without giving any symptoms. The defensive system of the body takes care of the slight amount of pus formed, which is absorbed through the lymphatics, or blood channels. Sometimes a dental granuloma is described as being a tumor, but this is not correct, as it is distinctly of infectious origin and histologically presents a picture of chronic inflammation. The lesion of course increases at the expense of the bone. A picture of a skull (Fig. 129) showing such a tooth will illustrate the condition. It shows a bicuspid, the root canal of which has probably been treated. The hole in the bone (*A*), with the many fine canals surrounding it, represents the amount of destruction which has taken place. Another picture (Fig. 130) shows a tooth with a chronic abscess, as seen under the microscope. This abscess is what fills the hole in the bone. It shows the end of a root (*A*), to which is attached a small sac (*B*). This has been stained with a connective tissue stain, so as to bring out the fibrous nature of the capsule (*C*) surrounding the lesion. The inner part shows three centers of broken down tissue and if examined with a high power lens it would be found to contain many vessels

surrounded by large numbers of lymphocytes, plasma cells and leukocytes. These have special biological functions. The first two are

FIG. 129

FIG. 130

said to neutralize and eliminate toxins, while the latter are of phagocytic nature, destroying and fighting the invading bacteria. Pus is continually formed in small quantities in the abscess. There is generally no outlet, the original opening through the root canal and cavity in the crown having been closed by the filling, so that the pus is taken up by the blood stream and carried away.

Condition of the Tooth Apex.—Periapical infection, especially if it is of long standing, causes changes in the cementum of the tooth. Nutrition is usually disturbed, the cells of the apical part of the peridental membrane may become destroyed and the cementum, which is very

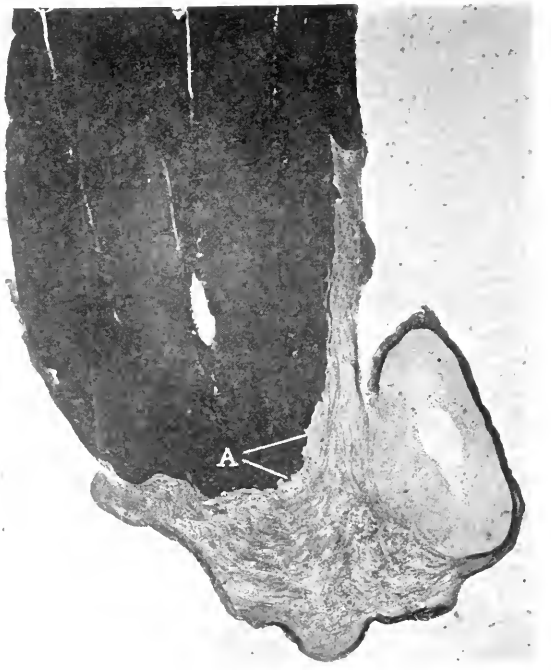


FIG. 131

porous and easily absorbs the products of inflammation, becomes pus-soaked and filled with bacteria. In this condition the tooth is an obnoxious foreign body which Nature tries to eliminate by osteoclastic absorption, starting on the surface of the cement, which then presents a roughened appearance (Fig. 131, *A*). Marked indentations are formed and the cement, and later the dentine also, dissolves. At times new cement is deposited, due to stimulation of cementoblasts, which have survived. This causes enlargements of the root end and often renders extraction of the tooth extremely difficult. The reason why an abscess of long standing is so stubborn and impossible to eliminate by any means other than surgical treatment is on account of the infection of the

apical part of the tooth root, which is a dead piece of bone and, like a sequestrum, has to be removed before healing can take place. The process of absorption indicates plainly that Nature wants to accomplish the elimination of the tooth. Fig. 132 illustrates a photomicrograph of a tooth with a blind abscess (*A*), showing absorption (*B*), not only of the outer layer of cement, but the entire apex of the root.

FIG. 132

Exacerbations.—If more pus is formed than can be taken care of and eliminated by means of absorption it may result in the formation of a fistula. This is generally known as a gum-boil. Everyone knows that a great deal of pus can be squeezed from a gum-boil several times a day and this makes it easier to understand that such pus, when drained into the system, must be injurious to the health.

MORE EXTENSIVE LESIONS CAUSED BY PERIAPICAL INFECTION.

If we consider the frequency of dental infections it is surprising how rarely we find extensive bone infection and serious involvement of the adjoining structures and the alveolar process. The reason for this is probably to be found in the bountiful blood supply of the bone in the immediate neighborhood of the roots of each tooth, from which a defensive system is built up to prevent the spreading of infection, carry-

ing away the products of bacterial activity so successfully that there is seldom even an outlet, or fistula, formed to the face or gum. Peridental infections sometimes result in extensive lesions of the jaw, as well as radicular or periodontal cysts, which are also of the infectious type. It is a deplorable fact that they are generally not recognized for a long time and are often treated for months by means of root canal medication without making an accurate diagnosis.

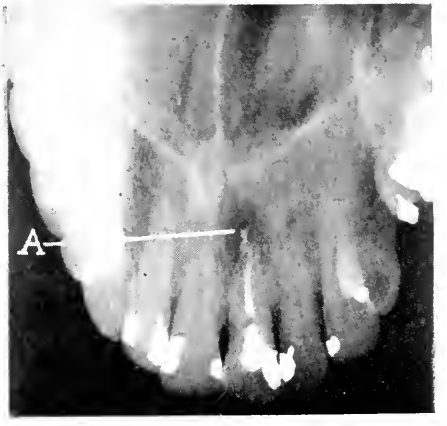


Fig. 133

Fig. 134

Ostitis.—This is a bone infection of a more extensive type, developing often from periapical infections. It may be of the suppurative type, accompanied by violent acute symptoms, but more often is of chronic character, developing from chronic periapical infection. This type is called granulating ostitis. It may involve large portions of the jaw

and several teeth without causing much swelling or pain. A roentgen picture of granulating ostitis is shown in Fig. 134. Note the large, dark area of irregular outline, marked *A*. Fig. 133 shows a picture of an ordinary blind abscess (*A*) for comparison.

Diffuse Osteomyelitis.—This condition is, fortunately, very rare, but when it occurs is a serious disease. It spreads, as a rule, from one side of the jaw to the other and with the best of care it often takes months for complete recovery. Fig. 135 shows such an infection, which started from an abscessed tooth, improperly treated. When the dentist finally extracted it the disease had already spread all over the jaw, as indicated in the roentgen picture by the dark channels extending throughout the jaw.

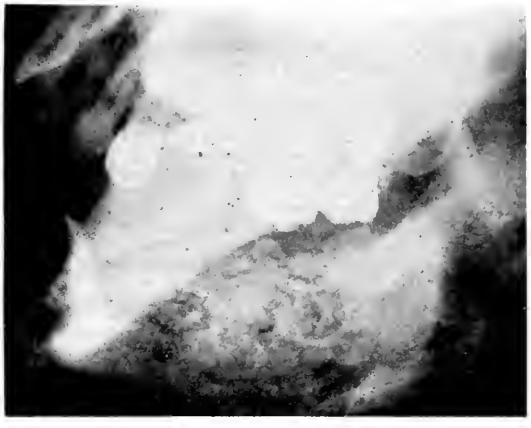


FIG. 135

Cysts.—Cysts are found quite frequently. The writer has seen a large number during the last few years. They are caused by chronic abscesses and as their secretions accumulate they increase to enormous size. They form a large cavity in the bone, which sometimes reaches the size of a hen's egg and always contains pus. The bone itself is not infected, but is absorbed and becomes so thin sometimes that it can be bent when pressed with the finger. In the upper jaw cysts may encroach on the nasal cavity or develop inside the maxillary sinus, sometimes filling it almost completely, a condition which is very difficult to diagnose. In the lower jaw they are found in the body of the mandible, as well as in the ramus. Radicular cysts sometimes have apparently no connection with a tooth root. In such cases the guilty tooth may have been extracted, the cyst having escaped notice at the time, or there may have been left in the jaw an epitheliated granuloma, which developed into a cyst later. Fig. 136 shows such a case. *A* indicates the cyst.

The diagnosis of a cyst is easily made by means of roentgen pictures.

The examination should be made on large films or plates, as the small ones seldom cover more than a part of the lesion. The cyst cavity

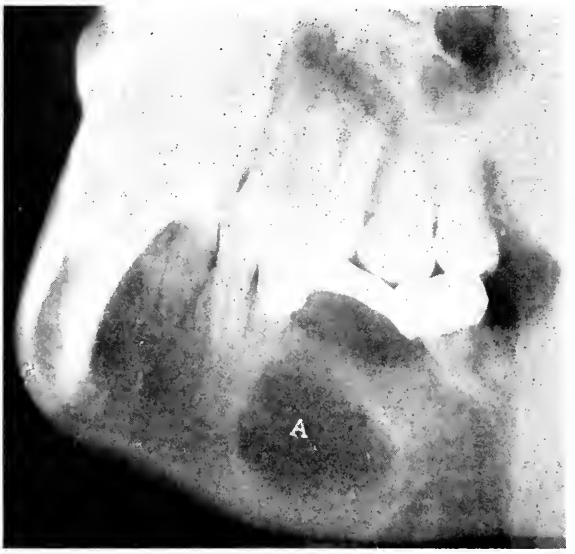


FIG. 136

appears as a black area on the negative because it decreases the resistance which, in normal bone conditions, is put in the way of the rays.

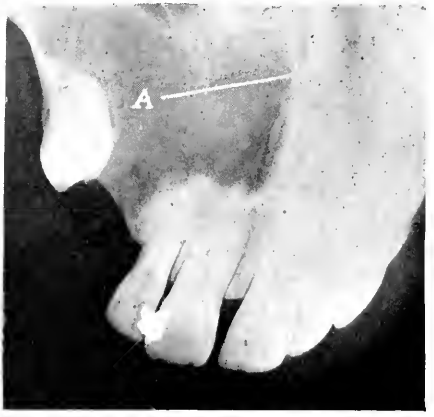


FIG. 137

The bone immediately surrounding the cavity, however, is usually cortical and dense and so we find the typical picture of a cyst showing a light, but distinct, surrounding line (*A*), well illustrated in Fig. 137.

Infection of the Maxillary Sinuses.—Maxillary sinusitis in both the acute and chronic types is, in a large percentage of cases, due to dental infections. Abscesses on the upper bicuspids and molars are frequently the cause of infection of the maxillary antra. Fig. 138 shows the intimate relation of the tooth apices with the antrum (*A*). Only a very thin layer of bone separates the tooth from the mucous membrane of the sinus. Acute sinus infection may be caused by careless instrumentation or the pushing of an infected root into the antrum. Chronic maxillary sinusitis with polypoid degeneration is a condition which also often occurs without the patient's knowledge and may be discovered only during a routine examination. If abscessed teeth are found in the upper jaw the sinuses should always be investigated, and in all cases of maxillary sinus disease the examining physician should insist upon roentgen films of the teeth.

FIG. 138

Ludwig's Angina.—Ludwig's angina is also one of the consequences of alveolar abscesses. Most cases observed by the writer have followed the extraction of teeth, the infection spreading rapidly and causing an acute infiltration of the soft tissues of the floor of the mouth. The board-like swelling presses the tongue upward and backward into the pharynx, which causes the well-known symptoms, difficulty in breathing and swallowing and great anxiety on the part of the patient. The mortality from this infection is very great. Death may occur in from ten to twenty days.

INFECTED TEETH AS A SOURCE OF SYSTEMIC DISEASE.

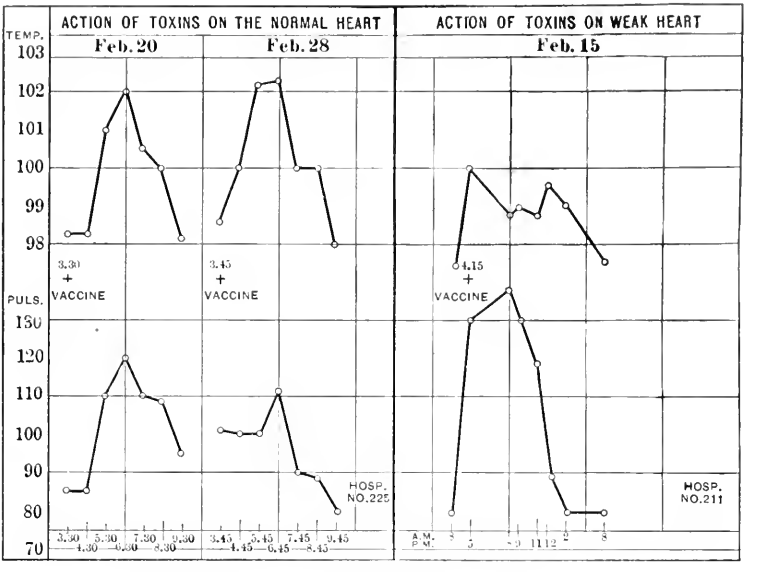
Since the days of Hippocrates it has been known that infections of dental origin may be accompanied by serious systemic symptoms. This celebrated writer, who was born four hundred and sixty years before Christ, makes the following statement: "At the approach of dentition pruritis of the gums occurs and fevers, convulsions and

diarrhea, especially when cutting the canine teeth." The eruption of the teeth, therefore, must have been frequently attended by acute infection. This is the first writer who mentioned the effects of dental infections upon the general system.

In any infection we have both local and general effects. The general effects in acute infections come on suddenly and are well marked, even alarming. This is principally due to the fact that the cause is a strong injurious agent, such as very pyogenic organisms. In chronic inflammation we have a reaction to a mild injurious agent and the systemic effects come on slowly and may even be so slight that no symptoms occur as long as the protective forces of the body are able to take care of the condition. However, as soon as the general resistance of the body is lowered by such things as debilitating disease, poor physical condition or pregnancy, or if the local resistance of a part is decreased by exposure or interference with nutrition, serious complications may gradually develop and frequently the patient is not aware of the trouble until irreparable harm is done. The following observation of two patients may serve as an illustration. The first, a woman with a perfectly healthy heart, Hospital Case No. 225, and the other, a patient with a weak heart, Hospital Case No. 211, both had the same amount of vaccine injected. The first patient, a well developed and well nourished woman, had been suffering from chronic arthritis for twenty-one months. Lungs, normal; heart sounds regular and of good quality. On February 20 vaccine treatment was begun. Injection of 75,000,000 typhoid bacteria with 100 c.c. of normal salt solution was made at 3.30 P.M. into the median basilic vein. She had a definite chill, which lasted twenty minutes, but otherwise there were no heart symptoms. Temperature and pulse curve shown on chart (Fig. 139). By 9.30 these were perfectly normal. A second vaccine treatment of 100,000,000 bacteria, given eight days later, produced a similar result.

The second patient, a woman 36 years old, was admitted for chronic arthritis. Had had measles, diptheria and scarlet fever when a child; at the age of twelve, "St. Vitus' dance," which lasted two years; two attacks of pneumonia when fifteen years old and rheumatic fever seven years ago. Her present illness began eighteen months ago, when she noticed pain and stiffness in the knees. The joints of the fingers, elbows and shoulders then became involved. Present examination shows slight edema in ankles, teeth poor, glandular enlargement in submaxillary region on both sides. There was a systolic murmur of the heart, but no evidence of physiologic disease. On February 15 at 4.15 P.M. the patient received a vaccine injection of 75,000,000 bacteria intravenously. At 5 P.M. there were signs of reaction, chill, typical spasmodic shaking, but no complaint of cold. Had marked cardiac symptoms at 9 P.M. Patient was dyspneic, cyanotic and coughing. Sputum was salmon colored. Distress, dyspnea and headache lasted until about midnight and the next day there was still tenderness and palpitation over the precordia (Fig. 139, *B*).

These two cases illustrate the different effect on two patients of a small and limited amount of toxin, the same in both cases. The healthy patient, in this case the one with the strong heart, can easily take care of a slight infection, while another patient not in perfect health may suffer from a similar cause most severe effects.



A FIG. 139 *B*

Systemic Effects from Acute Dental Infections.—Constitutional effects are nearly always present in acute infection. They are evidenced by fever; that is, raised temperature, quickening of the pulse and respiration rates, headaches, flushing of the face, brightening or injection of the eyes, dry hot skin, constipation, highly colored urine and, in serious cases, perhaps also delirium at night.

Leucocytosis is called forth in nearly all cases of acute infection as a protective reaction by stimulation through the toxins of the bone marrow and other places where leukocytes are formed.

Discharges are especially marked in the critical stage. They are profuse sweating, sometimes hemorrhage from the mucous membranes and often diarrhea.

All these constitutional symptoms may be slight or well marked, according to the physical health of the patient, as well as to the virulence of the infection. In serious cases the absorption by the blood circulation may become so extensive that we speak of the condition as a blood infection, or septicemia. While we generally get absorption both of bacteria and their toxins we may distinguish various typical conditions.

Bacteremia.—Bacteremia is a condition in which the bacteria are absorbed from the original seat of infection and circulate and grow in the blood. If, however, the bacteria are very pyogenic and elaborate toxins we employ usually the general term of septicemia. The symptoms are those already described. In addition, however, there is usually a chilly sensation or actual chills. The pulse becomes more rapid and progressively weaker and the temperature rises until death occurs. (See Fig. 140.)

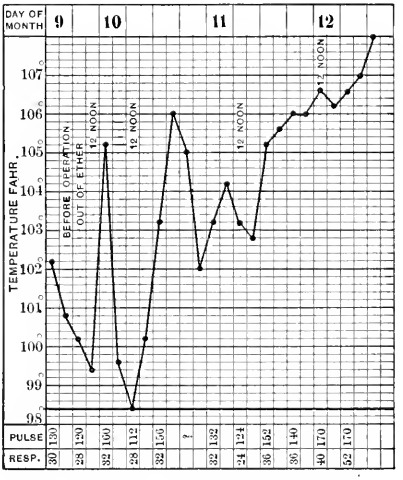


Fig. 140.—Puerperal septicemia; death. (Ashhurst, Episcopal Hospital.)

Pyemia.—This blood infection is generally due to a cluster of bacteria or an infected blood clot entering the circulation. It then usually lodges in a capillary and the bacteria produce suppuration in the new location. Thus a new abscess forms, which is called a metastatic abscess. This may be located in any part of the body and is frequently found in the heart, lungs, liver or joints. Suppurative lesions in the bone are most frequently the seat of the primary focus. Fig. 141 shows a temperature chart in a fatal case of pyemia.

Toxemia.—If the bacteria remain in the primary lesion and only the toxins (both true, special toxins, and the poisons produced by the biological activity of pyogenic bacteria) are absorbed the condition is spoken of as toxemia. This should be differentiated from autointoxication due to poisoning by non-bacterial substances such as drugs and products of perverted metabolism. According to the amount and quality of the toxins and the reaction of the individual we speak of acute and chronic toxemia. The latter will be discussed under systemic effects from chronic infections. Acute toxemia cannot very well be distinguished from septicemia by symptoms, as these are almost the same. It yields quickly to treatment, however, and if the cause

(the bacterial focus) is removed the symptoms usually disappear promptly. If, however, the septic focus is not found it may terminate in septicemia.

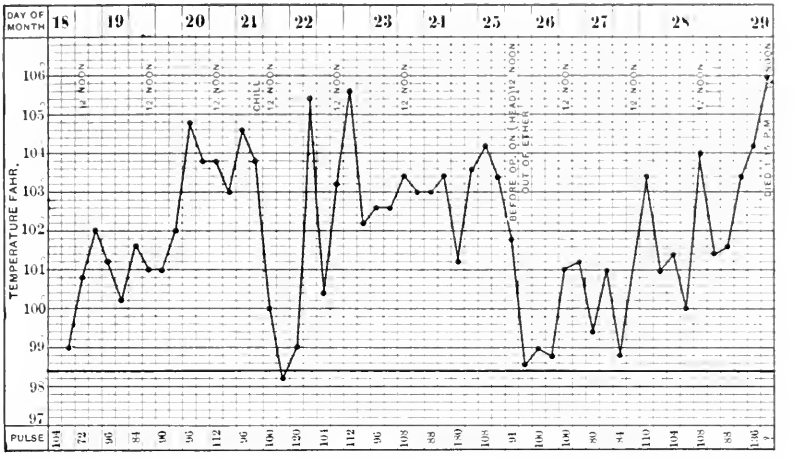


FIG. 141.—Temperature chart in pyemia; acute osteomyelitis of calcaneum; abscess of brain; death. (Ashhurst, Episcopal Hospital.)

Sapremia.—Sometimes dead tissue, such as a dead pulp, remains in the body without being infected by pyogenic bacteria. Saprophytic bacteria may then develop and form ptomains which, when absorbed,

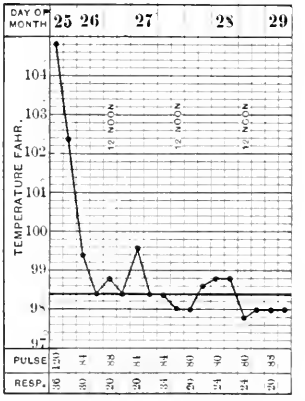


FIG. 142.—Sapremia; rapid fall of temperature after evacuation of retained secundines. (Ashhurst, Episcopal Hospital.)

give symptoms similar to toxemia. As long as the dead tissue remains there will be constitutional effects, but these disappear after removal and there is usually a prompt restoration of health. Fig. 142 shows a

temperature chart from a case of sapremia. The temperature fell immediately after removal of the dead tissue.

Systemic Effects from Chronic Dental Infections.—In chronic infections lesions such as have already been described often start and persist for a long period without local symptoms and we rarely get acute general manifestations, such as fever and other symptoms connected with septicemia due to acute infection. It is now conceded, however, by most pathologists of this country that a number of general diseases are caused by the continued absorption of bacteria or their poisonous products from such a chronic inflammatory focus. This transportation of an infection from the primary lesion to another place is spoken of as focal infection.

The Focus.—The focus is the name given to the primary infection, from which bacteria or their toxins may be transported to other parts of the body. It may be found in any part of the body, but the nose or throat and adjacent sinuses, the oral cavity, the alimentary canal, and the genito-urinary system are the parts in which foci are found most frequently. Foci are not always apparent and are often only recognizable after a most careful examination by the specialist.

Oral Foci.—It is a mistake to spread the impression that diseases of the mouth and teeth always play a predominant part, as much as it is a mistake to think that the teeth and their investing tissues are organs apart from the rest of the body reacting, for some mysterious reason, differently from the rest of the human organism. Various oral lesions of infectious origin have already been described. The blind abscess or dental granuloma among these is the most frequent cause of systemic disease, but also pulp infection, pyorrhea and other bone infections of the jaws which are of less frequent occurrence may play an important part. The bacterial flora of the mouth includes not only a large number of saprophytes which live on dead tissue, but also an extensive variety of the pyogenic organisms, among which especially prominent are the different types of streptococci, the staphylococci, pneumococci and micrococcus catarrhalis.

Mode of Distribution of the Infection from Oral Foci.—Dental abscesses with fistulæ and pus pockets discharging into the mouth furnish a continual supply of infectious organisms which may cause diseases of the throat, lungs and mucosa of the alimentary canal. From a deep-seated focus with no outlet infection may take place through the lymph. There are two groups of lymph glands which drain the jaws and teeth. The submental glands take care of the region of the lower incisor teeth. The three submaxillary lymph glands on each side drain the rest of the teeth and their investing tissue. All are tributaries of the lymph nodes of the neck. These glands are hardly noticeable when normal, but in acute infections they become enlarged and very tender to touch. In chronic infections they may also become enlarged, but are harder and not painful on palpation. The lymph vessels may also become involved and in this case we speak of the

condition as lymphangitis. The lymph glands are more liable to be enlarged in children, but lymphatic infection is not at all rare in adults. The most important path of absorption, however, is through the circulation. Acute infections always cause more or less involvement of the general system, but also in chronic infections the disease is rarely entirely localized. Bacteria, or the toxins formed by bacterial absorption, or both, are taken up by the blood stream in the focus, which is always very rich in primitive vessels, causing a bacteremia or chronic toxemia. The result, however, does not cause cross symptoms, as in acute septicemia, but is of so mild a character that the patient's health may be considerably undermined before any marked effect is noticeable.

Secondary Lesions.—The bacteria or toxins taken up by the blood may be carried to any part of the body by the circulation and produce new disease, or secondary lesions. The type of secondary disease and the part affected depend upon a great many factors. Predisposing causes and debilitating diseases are very important, while traumatic injury, exposure to fatigue, malnutrition, pregnancy and other conditions which lower the resistance give opportunity for bacterial invasion. The varieties of bacteria, of course, probably have tendencies toward growth in certain tissues and according to Rosenau's latest studies, members of the same type may develop affinities for certain tissues. Streptococci taken from an infected heart muscle would, if injected into the blood stream of another animal, again elect to invade the tissues of the heart.

Secondary diseases are, however, also caused by absorption of bacterial toxins only. While these may not be of sufficient strength to cause acute toxemia they can, in susceptible patients, cause serious disturbances, both general and local. Especially delicate tissues are affected so that physical discomfort and mental depression may result.

Establishing Proof of Systemic Infection.—Often it is difficult to determine whether absorption takes place from suspicious teeth. As a rule there is little doubt as to what should be done with infected teeth, from a purely dental point of view, or even simply for the sake of cleanliness. No one who has studied the tooth and bone pathology of conditions caused by old pus-soaked teeth, or who has experienced the odor of one which has been removed, will hesitate to recommend extraction. There are, however, cases where we might recommend more conservative treatment if we were sure that no absorption was taking place.

Two tests are available to decide whether absorption of bacterial poisons has occurred. One is a blood test, the other a skin test, such as that used in testing for food poisoning. In conjunction with Dr. Lawrence of Boston I have experimented with these tests. The following is an example.

Mr. G., a chauffeur, had been unable to drive a car, on account of pain in his back and shoulders. Roentgen pictures of his teeth (Figs.

143 to 152) showed many devitalized teeth and several abscesses, (marked *A*, *B*, *C* and *D*); also a pus pocket (marked *E*), and careful examination

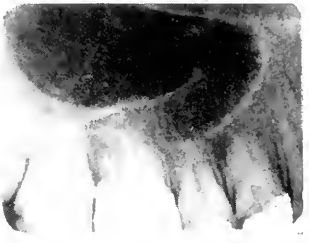


FIG. 143

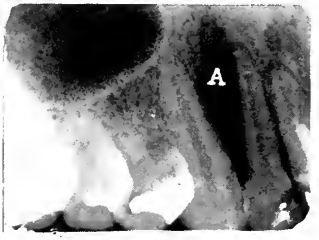


FIG. 144

revealed no other possible cause for his condition. The blood test, known as the complement-fixation test, showed a reaction to two types of streptococci, the toxins of which were being absorbed. The skin

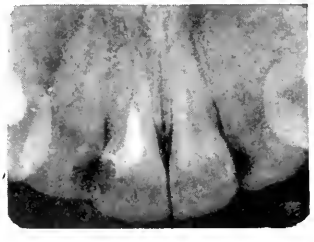


FIG. 145

FIG. 146

test was positive to the same organisms. The abscessed teeth were extracted, cultures were made from each, and again pure cultures of the same organisms were obtained. The patient improved so much

FIG. 147

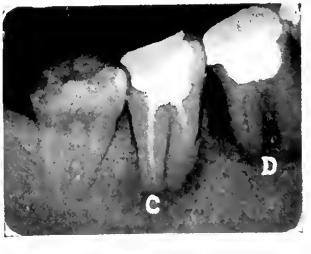


FIG. 148

after removal of the focus that he was soon able to go to work and is now driving a truck.

General and Special Diseases which may Originate from Oral Infections.

In the following list are enumerated some of the special and general diseases which may have their origin in the oral cavity. It should be clearly understood that all these conditions may arise from a focus in any part of the body and that diseases of the teeth are not the only etiologic factors, nor even the most important ones. In compiling this list the writer has aimed to include only such diseases as are at present generally conceded to be caused by focal infection.

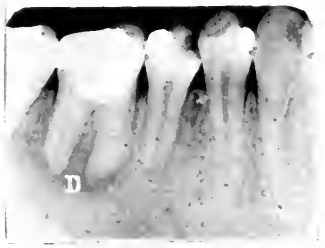


FIG. 149

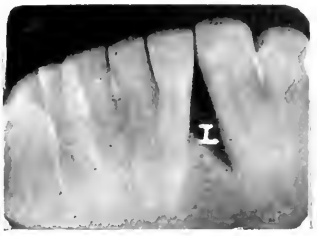


FIG. 150

Laryngology, Rhinology and Otology.—Maxillary sinusitis in its various clinical forms is quite often caused by dental infections. However, in cases which are clearly of nasal origin infected and devitalized teeth may become a contributary cause which, if not removed, will prevent complete recovery. Tonsillitis and pharyngitis may occur from pus discharged into the mouth. Ear infection, such as acute otitis media or chronic purulent inflammation of the middle ear and tympanum may be caused by direct invasion through the Eustachian

FIG. 151

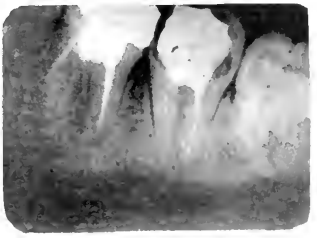


FIG. 152

tube, or the infection may be transported by the circulation. Pain in the ear, so-called otalgia dentalis, is frequently only a reflex pain from some cause in or about the teeth.

Ophthalmology.—Disturbances in the eye may be brought about by nerve irritation, or through hematogenous or direct infection. Infectious conjunctivitis in children is often caused by rubbing the eyes with the fingers, which have been put into the mouth to feel an aching

tooth, which discharges pus through a fistula. The pus may get on the child's finger and be brought into direct contact with the eyes. Hematogenous infection may cause infection of other parts of the eye, such as iritis and retrobulbar neuritis.

Pediatrics.—Children are frequently victims of focal infection causing grave and sometimes irremediable conditions, such as heart disease (endocarditis), kidney disease (nephritis) and acute inflammation of the joints. Acute or chronic lymphadenitis is also a common occurrence in children.

General Medicine.—Septicemia and pyemia may be caused by infections from the teeth, but are of comparatively rare occurrence. Toxemia, however, is more frequently observed. Many obscure troubles are due to absorption of a small amount of toxin. Such symptoms may be fatigue disproportionate to the slight exertion occasioning it, inability to do the accustomed day's work, mentally or physically, benumbed mental activity, requirement of an abnormal amount of rest, loss of weight, grayish or sallow skin, and a rise in the temperature in the afternoon or evening. A perfectly healthy person may be able to eliminate a certain amount of infection, but sooner or later more serious results are apt to occur. Lowering of the body temperature by exposure to cold or wet may give rise to more or less vague rheumatic conditions in the muscles, (myositis), joints, (arthritis), or nerves, (neuritis). Cases of acute multiple arthritis from dental infections are not uncommon and usually improve rapidly after removal of the focus. In chronic infections, especially arthritis of long standing, the results are not so gratifying. The joints may present tissue changes which are beyond repair from an anatomical point of view. The removal of the focus, however, usually relieves symptoms of pain and swelling and prevents reinfection from this cause.

Endocarditis and nephritis are also caused in the adult by transported infection from a focus. In heart infections there is the additional danger of damage due to absorption of toxins from any infectious lesion, not necessarily the cause of the disease.

Gastro-intestinal disorders are frequently caused by pus from the nasopharynx or mouth being swallowed into the stomach. According to many writers the most common disturbances are septic gastritis, appendicitis, colitis and gastric and intestinal ulcers.

Conclusion.—The lesson to be learned from these studies is the importance of laying more stress than ever upon the preventive side of dentistry. Preservation of the dental pulp and its sequel, prevention of periapical infection, starts at an early age. Preventive dentistry should begin with children and no treatment will further this object more than the excellent work of the dental hygienist.

CHAPTER XI.

DENTAL PROPHYLAXIS.

By ALFRED C. FONES, D.D.S.

THE CELL.

In order to appreciate health it is necessary to be familiar with the facts concerning the individual cell, and the effect of various influences upon the unit must be studied before an understanding can be had of the action and influence upon the cells in the aggregate. If a drop of water is taken from the side or bottom of an aquarium and put in a glass under the microscope, a minute jelly-like mass may be seen. Its outer circumference slowly changes its shape, while near the center there is a very minute globule termed the nucleus. This is the lowest and simplest form of animal life and is known as the ameba. This simple cell has seven distinct properties. It may extend its wall in projections like false feet, or protuberances, or may flatten itself out in a long line, therefore it has the property of elongation. When irritated by being brought into contact with dilute acid it will contract into a round form; hence, it has the property of contraction. These two properties give it its power of motion. It appreciates the presence of irritants, of food and of thermal changes, therefore it has the power of sensation. It can digest food and discard waste tissue, therefore it must have the properties of secretion and elimination. The cell and nucleus have the power of dividing themselves in two, thereby forming two cells. It has the power of reproduction, and the new cells have the property of growth.

When all of these functions or properties of this simple cell are working normally, the ameba is in a state of health or balance. Rob it of one or more of its properties and it is diseased. Stimulate the cell by applying certain agencies and its motions become more rapid, it consumes its food more rapidly, it will subdivide and reproduce itself more rapidly. A greater stimulant will cause a still greater activity, but if this is continued the cell soon becomes exhausted and paralyzed from exertion and the ultimate result will be death. The reverse takes place under sedation produced by applying cold. The motions become slower, also digestion and reproduction. If the temperature is dropped too low, the cell dies. Pollute the water or rob it of its oxygen and the cell dies. Cell life is maintained chiefly by a chemical process of oxidation. It must have water and it must have a food supply to replace the lost substance which is gradually being utilized

in performing its various properties and functions. It is therefore apparent that cell life is dependent upon oxygen, water and food, a proper temperature and removal of waste matter.

Nature, in the building of all matter, builds from the unit. Although the atom is the smallest unit, the molecule of the mineral kingdom and the cell of the animal and vegetable kingdoms are the general bases for study. All earthly creations visible to us are formed on this one plan. The trees, the flowers, the grass, the mountains, the beach, the sea, all animal life, including man, each is made by the combining of these units, all working with an intelligence and subject to chemical laws far beyond our comprehension.

Why it is that the contents of the cell, which is called protoplasm and which appears to be nothing but a jelly-like mass, has the property of manifesting life and intelligence, is difficult to understand. This substance can be analyzed and even the proportion of its elements estimated, yet what unseen force imbues it with energy and intelligence and what becomes of this life-giving power when the cell dies and disintegrates, is not known. Cell action can be studied, and the cell can be supplied with the essentials for growth and development. It is a realized science that in animal life, certain factors properly applied at the proper age can greatly develop its function and intelligence, the same as in vegetable life, but it cannot be explained. It is known that all manifestation of life and of intelligence is expressed through this matter contained within the cell.

In the gradual evolution of these simple cells, like the ameba, combining to form larger and more complex organisms, it is found that the cells choose a specialty of two or three of these properties, and those whose specialty is the same are grouped together. As animal life develops into higher planes the cells become more proficient in their specialties, until in man is found the greatest variety of highly specialized cells in animal life. While the ameba possesses a balance of seven properties, some of the specialized cells of man concentrate on but one function. It may now be seen how these cells of man that have undergone a slow evolution of millions of years to reach their present degree of intelligence are reflected in this low and simple order of life—the ameba. It has been stated that the ameba has seven properties. Its power of contraction is exemplified in the muscle cells of the human body, whose specialty is contraction. These cells are capable of wonderful development and training. The finger touch on the piano keys, the surgeon with his instruments, the dancer, the juggler, the athlete, the artist, and the artisan, all demonstrate how these minute individuals receive impressions from the brain and nerve centers and interpret them with such wonderful intelligence. The nerve cells specialize on the transmission of sensation and vibratory influences to and from the brain. Digestion and elimination, being very much more complicated in higher animal life, require innumerable cells which perform separate functions—the passing on of food, the secretion of

fluid for its solution and its preparation for absorption. In the blood stream are cells floating along, each intent on its special duty. The liver, with its cells actively engaged in preparing the waste products for elimination by the kidneys, the sweat glands, the lungs, the brain (that wonderful terminal station, headquarters for all orders) all are composed of these specialized units working together like so many people in an immense city, each adding his mite in labor and service for the common prosperity and health.

The intelligence displayed by the individual cells of the body is the marvel of scientific investigators in physiology and pathology. Much is yet wrapped in mystery and many years will pass before some of the deep problems of nutrition and the hard-fought battles waged against disease will be fully understood.

When the body is abused this abuse is imposed upon millions of intelligent beings who do their utmost to offset ignorance and wilful acts by patiently combating the impositions and trying to correct and repair the damage wrought. In early youth the cells are in abundance and the supporting structures are but partially formed. In adult life the work of the cell is completed, and the intercellular structure is in predominance. The great period for structure building and for the guidance of proper cell development, physically and intellectually, by applying scientific factors to properly influence this result, is from infancy to twelve years of age.

As a spider spins his web so do these minute cells create tissue to aid them in their work. The individual reflects the composite texture and make-up of the aggregate cells of the body, and the period for molding, refining and advancing this cell development to its highest plane is in early youth.

Factors for Cell Life.—The scientific factors for influence are numerous, but there are a few that stand out conspicuously. First of all comes pure air, for cell life is dependent upon constant oxidation. Next comes a proper food supply. The character of food will eventually determine the character of the cell, and as the body is physically composed of millions of cells, the food supply in a great measure determines the character of the individual. This is exemplified in the glutton, the drunkard or the savage. *What* is eaten, *how much* is eaten, and the *manner* in which it is eaten, are some of the chief factors for health balance. The question of food values, the quantity consumed and the importance of thorough mastication and salivation should be a study for all hygienists.

Next comes cleanliness, for if disease is to be prevented clean food, clean water, clean mouths, clean bodies and clean environments are necessary. Mental attitude is another powerful factor and should have fourth place. Self-control, optimism, that mental poise that can discard fear and worry, that holds an even balance under varying circumstances and that can radiate good cheer and kindness through their health-giving influences to every cell of the body, are elixirs

unequaled in the building of the character as well as in regulating a perfect balance and functioning of the entire system.

Although heredity, too, plays a strong part, yet the first four factors named can greatly modify the inherited disposition of the cells if wisely applied. When we speak of coarse natures, we speak of an unfortunate inheritance of a type of cell life that might have been greatly softened and modified in childhood.

Exercise is also exceedingly important, for rest means rust even in animal tissue.

If man lived what is termed a "natural" existence, which means, in other words, an outdoor and primitive life, with simple coarse foods and work or exercise in the open air, which develop the animal side, there would be but little need of the physician or the dentist. The coarse food would mechanically clean and polish the teeth by friction, and the out-of-door exercise or work would cause an enforced breathing which would mean a greater intake of oxygen to burn up the slag and waste products in the system. But this so-called natural existence is not possible to 70 per cent. of the people of the present day. Their very existence depends upon their work or artificial life in the cities, and the yearly increase in numbers in the cities rather proves the preference for the city over the country. Therefore this health problem of city life must be solved. The factors which are productive of health in the animal life must be substituted artificially. The passing generation cries that children are being brought up too much by the teaching of science and the book instead of in the good old-fashioned way of letting nature look after them. Take, for example, the wild rose of the field that depends upon sunshine and shade, warmth and moisture and proper soil for its growth. Nature does not and cannot always supply these in sufficient degree and in proper balance, and although the flower is beautiful it cannot be compared with the beautiful rose that the horticulturist can grow when these essentials are scientifically and artificially supplied. In the hothouse the correct temperature can be maintained, moisture in sufficient quantity supplied, sunshine and shade regulated at will and fertilizers essential to stimulate growth added to the soil. The work of Burbank in scientifically handling vegetable life is well known and our modern methods of agriculture and fruit raising. The wonderful feats of the horse, hurdling, running and trotting are due in great measure to the scientific training by man. Many instances can be given in which nature far exceels her natural state of environments if the essential factors she needs are supplied artificially and scientifically in sufficient abundance and degree.

And so it is in the growth and development of the city child, and even in that of the adult. If the proper factors for health can be scientifically administered, it is possible to grow children as far superior to those of the present-day average in the public schools, as the American Beauty is superior to the wild rose. Man has had his progressive period; woman is having hers. The coming one belongs to the children.

THE ALIMENTARY TRACT.

Before confining thought and attention chiefly to the teeth and their surrounding tissues and considering how disease may be prevented, a few simple thoughts regarding the body must be presented, that it may be better understood how important a part the mouth plays for health or for disease. There is no better way of doing this, perhaps, than first to consider a country with its many people, and show the factors upon which it is dependent for health, for a close analogy may be drawn between the life of a simple cell, the individual and the nation as a whole. Egypt is the best for illustrating this thought, for here is found a strip of life running through a region of apparent death. Suppose a piece of green cloth, six inches wide and a hundred feet in length, was laid on the sands of the seashore, running straight up on the beach from the water's edge. If in the center of this cloth was laid a long white string to illustrate the river Nile, it would be a fair representation of Egypt. The Nile runs through a desert and the water with its life-giving power has created a living body close to its borders. In this living body are millions of people who are dependent upon this alimentary tract or river for their existence. Along the banks may be seen the water buckets, operated by the natives to supply their fields and gardens. In the season of the overflow the soil is soaked with moisture, the crops are plentiful and there is ample for those who will work. Canals or arteries lead from the river bank across the fields to supply life and growth to the soil that would be desert waste without it. If it were possible to poison the source of the Nile so that its waters carried their life-giving properties no longer, but contained some chemicals that were destructive to plant life, or sufficient sewage to poison the inhabitants, Egypt would soon cease to exist. Just in proportion to the amount of poison carried down the river would the country and people suffer from starvation and disease. The bodies of all animal life are constructed around their alimentary tract. The lowest forms of cell life when changing to a higher organism, find it essential to develop first a mouth and digestive tract, for the intake of food is of first importance with all material life. The body with its millions of cells is dependent upon the flow of nourishment through the alimentary tract and as the individual lives and feeds so will his body thrive or deteriorate. The mouth is the vestibule or gateway to the whole system. All the nourishment and food supply to the body must pass through this one portal. The placing of the food in the mouth is a voluntary action and it can be controlled as long as it remains there, but the moment it is swallowed it is beyond voluntary control and is sent on the mysterious journey called digestion, absorption and assimilation.

Assuming, first, that the food eaten is clean and pure and above criticism, and enters a clean mouth, is properly masticated and swallowed, digestion take place normally, provided the mental attitude

be one of tranquillity during this period. If the mind is excited or irritated, it will send depressing messages throughout the body and the process of digestion is retarded and disturbed.

Under such clean conditions the normal processes of digestion can take place with a minimum amount of effort and energy being expended by the tissues in their work, and the product after digestion is fit for the blood stream to offer to the cells of the body the nourishment they need to perform properly their respective functions. But the reverse situation exists regarding the mouth. The food may be clean and pure but the mouth unclean.

Decomposing Food Débris.—In discussing the harmful effects of decomposing food in the mouth, the subject cannot be better presented than by giving some of the thoughts of Dr. E. C. Kirk from a paper read by him in Providence, R. I., October 16, 1900, and published in the *Dental Cosmos* in May, 1901, entitled "Some Considerations Relative to the Infant Mouth."

Regarding the artificial feeding of infants he refers to the training of the nurse to sterilize the milk and feeding apparatus in order that the milk shall be delivered to the child's stomach free from bacteria "which when present in the food supply so alter its composition as to reduce its nutritive value and, what is still more important, set up decomposition processes within the alimentary tract of the infant which are direct causes of irritation and disease to the infant organism."

Great care having been taken in preparing the food and in feeding, no attention was paid to the film of milk left in the mouth after feeding. It is apparent that if fresh milk is poured into a bottle that has contained sour milk, infection of the fresh milk will immediately take place. In the feeding process the sterile milk passing over the infected surface caused by the residue of the last feeding at once infects the milk.

Dr. Kirk says, "There can be but one result: fermentation of the infected fluid begins in the stomach; putrefaction of the proteid elements may take place; quantities of gas are formed, distending the walls of the stomach and intestines, causing pain and irritation, further increased by the irritating effects of organic acids which are end-products of this fermentative process. Digestion is interfered with or arrested, the fermenting mass of food becomes a mechanical as well as a toxic irritant; diarrhea sets in, the whole nutritional process is interfered with and development is damaged in proportion to the length and severity of the attack.

"The rational remedy for this state of affairs is clear when once the conditions to be therapeutically met are understood. In the first place, removal of the primal cause by thorough oral cleanliness and sterilization in so far as that end may be obtainable. This may be practically accomplished by wiping the mucous membrane with a saturated solution of boric acid to which borax has been added in the proportion of ten grains to the ounce, or with a very dilute solution

of phenol sodique, one-half dram to the ounce, applied on a cotton swab or with a soft linen handkerchief wrapped around the finger of the nurse."

Now apply the same principle to the growing child and to the adult. The teeth of a child between the ages of six and twelve years will present surfaces equal to twelve to sixteen square inches. In an adult the surfaces will average about twenty-five square inches. This means that if it were possible to peel the enamel off of each of the five surfaces of each tooth and place them side by side they would cover a piece of glass three and one-half inches square in the case of the child, and in that of the adult a piece about five inches square. This will give a rough idea of the amount of surface presented in the mouth to permit of the retention of a certain quantity of food that must decompose unless it is removed. The more perfect the teeth regarding form, occlusion and enamel surface, the more self-cleansing they are, and proportionately, the amount of food so retained is comparatively small. The mouths that present such ideal conditions are rare, especially among those who are born and live in the cities. Where the teeth are irregular in shape and position, are decayed and broken down, the amount of food that remains is considerable and the volume of decomposing material constantly being swept into the intestinal tract will eventually breed illness. In a growing child such mouth conditions are vicious. "Suppose," said a prominent educator in dentistry, "that a prescription was given to a mother by a physician, to mix, with each meal that the child ate, a half-spoonful of garbage. Would she carry out such a prescription, and if she did and the child became ill, would not the physician be liable for damages?" And yet in reality that is what is taking place in the average mouth of the children in our public schools and in the mouths of the great working classes. This constant drain of poison into the intestinal tract in child life causes an intestinal indigestion where bacterial products are absorbed into the system and produce fevers, headaches, eye-strain, anemia, malaise, constipation, and dizziness. Nature finally takes away the child's appetite and forces it to bed until a good house-cleaning of the body can be accomplished.

These poisons from the mouth are insidious and slow in action. Many can and do withstand them for years, but as the constant dropping of water will wear away the stone, so will the products of decomposing food in the mouth soon destroy good digestion and undermine the system.

Vaughn and Novy, in their book entitled *Cellular Toxins*, say, "The effect of a chemical compound upon the animal body depends upon the conditions under which and the time during which it is administered. Thirty grains of quinine may be taken by a healthy man during twenty-four hours without any appreciable ill-effect, yet few would be willing to admit that the administration of this amount daily for months would be wise or altogether free from injury. In the same

manner the administration of a given quantity of a bacterial alkaloid to a dog or a guinea-pig in a simple dose may do no harm, while the daily production of the same substance in the intestine of a man and its absorption, continued through weeks, and possibly years may be of marked detriment to the health."

It must be borne in mind that the manifestation of sickness does not come from the presence of bacteria, but from the poisons generated by the bacteria.

Abbott in his book on *The Principles of Bacteriology,* quotes Roux and Yersin who claim that the potencies of the poisons that have been isolated from cultures of Bacillus diphtheriæ have been determined by experiments upon animals, and it has been found that 0.4 milligram is capable of killing eight guinea-pigs. Please remember that four-tenths of a milligram represents but $\frac{1}{160}$ part of a grain. Aside from the products of decomposing food in unsanitary mouths we must seriously consider how much of the bacterial poisons may be generated in such mouths daily by the millions of microörganisms present, and whether these poisons are not of sufficient quantity eventually to weaken the organism and render the body susceptible to infection from the pathological group of microörganisms. In the battle being waged against tuberculosis, this feature will be given much importance, and the day is not far distant when some scientist will be able to compute with a reasonable degree of accuracy how much bacterial poison can be generated in twenty-four hours in a mouth containing decayed teeth and food débris.

Bacterial Propagation.—In considering the products of decomposing food with their detrimental action on the system, their action upon the human mouth, than which there is no better breeding ground for germ life, must also be considered. The mouth is an ideal incubator, for here we find all of the essentials for the propagation and development of these microörganisms. The right temperature, sufficient moisture, air, darkness and a menu to choose from that would tempt any member of this large family. Germ life is comparatively harmless when robbed of a food supply, but give it a pabulum upon which to feed, develop and multiply, and it becomes active and virulent. It must be borne in mind that all mucus-lined tracts of the body have their flora of microörganisms and that the individual must live among them, that the few friendly ones are company, but that too many are a crowd, and that in this crowd are our enemies who feed upon the host if they but get a chance.

An unclean mouth means an increased number of bacteria, and with increased numbers come increased dangers from infection. The cavities of decayed teeth harbor millions of these mischief-makers, as do also the food débris and calcareous deposits around the necks of the teeth. They may enter the mouth in a very subdued state, but under these favorable environments they soon multiply rapidly. The usual order is to consider their activity and growth in unsani-

tary mouths, but this will be reversed and the medium upon which they best are cultivated in the laboratories be first noted. The saprophytic class are those which exist upon dead animal or vegetable matter. The parasitic class prefers to gather its nourishment from the living host. Many of both classes can live in either medium, as occasion demands.

As the unorganized ferment of gastric or intestinal digestion has the power of changing the food by rearranging its elements, usually by a process of hydration, so do these mieroörganisms have the power of breaking down tissue or decomposing food and liberating its elements in their search for carbon and nitrogen. The media chiefly used in laboratories for cultures of mieroörganisms are bouillon with agar-agar, gelatin, potato, sugar and blood serum. If these are kept at the right temperature, at least to grow mixed cultures, the saprophytic class is quite easily developed, for the extracts of beef, sugars or starches form an attractive pabulum. Many of the parasitic variety can also be grown in these substances, such as the typhoid bacillus, anthrax and others, while the tubercle bacillus and the bacillus of diphtheria are cultivated in the blood serum. These culture media are all found in the average mouth, even to the blood serum.

When the teeth are decayed the amount of food retained in the mouth is considerable, but especial attention should be called to congested and bleeding gums. Here is an ideal medium for the propagation of infectious germ life, and it is not only the cavities in the teeth and the food débris, but also the pernicious condition of the gum tissue in unsanitary mouths, especially in those of children, that is of serious concern. The germs of tuberculosis or of diphtheria can here find a pabulum for their propagation and development, and undoubtedly the prevailing condition of the gingival borders of the gums is one of the most important steps toward infection. The bleeding and congested gums and the decomposing food is present, all that is now necessary is the bacterium.

All observant practitioners will readily agree to the statement that mouths that contain no congested areas on the gingival borders of the gums are exceptions. The dark red surfaces will bleed upon the slightest pressure, and in between the molars and bicuspids where the food can lodge undisturbed in ill-kept mouths, even a slight suction will start a copious bleeding. It will be the privilege of the hygienist to note in the treatment of each new patient how easily the gums will bleed upon the slightest touch of instrument or porte polisher. The oozing of serum and blood from these congested points is of equal importance in the consideration of infectious diseases of children with the decomposing of animal and vegetable matter found in the decayed teeth or around their surfaces. To those who have thoroughly investigated the subject, the mouth is now conceded to be a most important field for bacterial growth and systemic infection.

Tuberculosis.—One of the greatest battles being waged in preventive medicine is the fight against tuberculosis, and this fight can never be won as long as the mouth conditions of the mass of people remain as they are at present.

Scientific investigators are agreed that tubercular infection frequently takes place through the tonsils and the intestinal tract. If this is true, the bacilli must either be taken in with the food supply in sufficient quantities to prove dangerous, or they must find lodgement in the mouth in decayed teeth and congested gum surfaces. With unsanitary or septic conditions existing in the buccal cavity, many bacteria in a state of virulency are constantly drained over the tonsils and into the stomach. Any physical depression that lowers the normal resistance of the body might permit of the invasion of these pathogenic organisms.

The medical man must realize that the gingival borders of the gums present an area eight times greater than that of the crypts of the tonsils, and that in the average mouth the gums are congested and bleed readily. This provides the ideal culture medium for the tubercle bacilli. Add to this the lowered bodily resistance induced by the absorption of the poisons generated by the immense numbers of bacteria present in such mouths, and it makes a pathological combination that seriously hinders the medical profession from making any further greater reduction in the mortality from this disease.

In our state sanitariums, where the tubercular patients are segregated, the mouth conditions are deplorable. It is true that, with plenty of fresh air, good food and rest, the body can and does neutralize much of the poison. The resistive force is increased and the disease pronounced arrested; the word cure is cautiously used. Could the mouths of these patients be made sanitary at the beginning of the treatment and rigid rules enforced regarding their daily care, a marked benefit would surely be observed. When the mouth is clean and wholesome the liability to this form of infection is greatly lessened.

Systemic Infection.—If syphilis and wounds of the surfaces of the body are excluded there are but three ways, ordinarily, for bacteria to gain entrance into the blood stream: (1) Through tooth passes, such as root canals and diseased pericemental tissues; (2) through the tonsils and (3) through the intestines. Infection through the tonsils or the intestinal tract is dependent, in a great measure, upon mouth conditions.

In the consideration of the mouth as an avenue for systemic infection, the attention must be centered upon the soft tissues: the gums, the pericementum and the pulp, for these are the tissues chiefly involved in permitting of the ingress of bacteria into the lymphatics.

Although there are other phases of dental pathology which may produce a detrimental action, either locally or systemically, the following three conditions are most prevalent and by far the most serious: (1) Unsanitary mouths, with decayed teeth and decomposing food; (2) diseased pericemental tissues; (3) devital and infected teeth.

The toxic influence of unclean mouths is especially noticeable in

children, frequently producing headache, malaise, dizziness, imperfect vision, slight fevers, diarrhea, and a general condition of malnutrition. And these minor ailments can only be considered as secondary to the dangers of systemic infections which are frequently produced by the actual penetration of the bacteria through the mucous membrane of the tonsils, the pharynx and the intestines.

The next factor is that of the inflamed and diseased tissues supporting the teeth. For quite a number of years dental pathologists have repeatedly called attention to the dangers of these pericemental infections as a probable cause of systemic disease, and since Professor Noyes' definite demonstration of the network of lymphatic vessels in the pericemental tissues, even to the extreme borders of the gingiva, there can be no doubt of the ingress of bacteria through these vessels into the blood stream, and their subsequent localization in some of the other tissues of the body. There is much scientific and clinical evidence to prove that pyorrhea alveolaris is a cause of systemic infection which may be produced in three ways: (1) By the constant exudation of pus in the mouth and thence into the digestive tract; (2) the absorption, by the lymphatics, of the bacteria and their toxins present in the deeper areas of the infected tissues, (3) by the pumping action of loose teeth in their sockets during mastication, forcing bacteria and their toxins into the capillaries and thus into the blood stream itself.

The third phase for consideration is proving even more serious than the first two, for the *x*-ray has revealed to us infected areas within the bone tissue at the apices of the roots of the teeth which we have heretofore never suspected. These apical infections are found only upon teeth with devital pulps, and have remained so long undiscovered because the action of the streptococcus viridans is so subtle and usually produces no local soreness, pain, inflammation or pus.

Our research workers have clearly demonstrated that, under certain conditions, the streptococcus viridans in the apical infection becomes aggressive and migrates, developing a selective action which varies in affinity for different tissues of the body, and the work of Billings, Rosenow, Hartzell, Thoma and others has proved scientifically that they are the cause of many of the most serious systemic infections, especially those involving the heart, the kidneys and the joints.

The death of the pulp is due chiefly to dental caries and dental caries is so exceedingly common that it is difficult to find two school children out of a hundred with perfectly sound teeth, and even in early childhood our school children average seven cavities per child. Consequently there are few young people who escape a pulp involvement due to the penetration of the bacteria through the tooth structure, destroying this delicate and sensitive tissue. Pulpless teeth are, therefore, so prevalent that it is the exception for an adult over thirty years of age to present a mouth without one or more devital teeth which already have, or which may develop an apical infection. The work of the dental hygienist will be the most important step in the elimination of

systemic infection from devital and infected teeth, for her field of service includes the prevention of dental caries and subsequent pulp involvement.

THE PRINCIPLES OF DENTAL PROPHYLAXIS.

The initial cause of nearly all the pathological or disease conditions of the tissues of the mouth is the combination of microörganisms and food débris. Bacteria alone or food débris alone would be quite harmless in the mouth. Nearly all germ life, in order to become virulent, or its presence dangerous or even objectionable, must have a pabulum upon which to thrive. It is therefore dependent upon some attractive food supply in order to reproduce and multiply. It is known that foods will "spoil" if allowed to remain in a warm temperature for any length of time, and that in order to prevent this action the germs are killed by boiling or heating the food, tightly sealing it from the air in cans or jars that have just previously been boiled or have had boiling water poured into them, and allowing them to stand long enough for their surface to become sterilized.

Food may also be placed where it will be kept cold, as in an ice-box, where the presence of the ice will so reduce the temperature that the organisms are rendered sluggish and inert.

For years, many efforts have been made to find some drug or chemical that could be used in the mouth to kill all bacteria and thus make the mouth sterile, or at least to render them inert. The futility of even hoping for a sterile condition of the mouth has long since been demonstrated. It is impossible to sterilize the human mouth, and even if it were possible, such a condition could be maintained but a very short time. Therefore, if it is impossible to keep the mouth free from bacterial life, and as the combination of food debris and bacteria is the chief cause of dental diseases, is there not some way in which the food débris can be thoroughly removed? It is upon this thought that the principles of prophylaxis are based.

Dental prophylaxis is that scientific effort, either operative or therapeutic, which tends to prevent diseases of the teeth and their surrounding tissues. Correcting and restoring to normal function all abnormal or pathological conditions of the teeth, and maintaining that normal condition, is a prophylactic procedure. This includes practically all the operations in dentistry. The mere filling of a tooth cannot be termed prophylactic unless the operation is performed with a knowledge and skill that tends to prevent future decay at that point and that will restore the surface of the tooth to normal contour and normal function. Crowns and bridges, root-fillings, approximal fillings with proper contact points, and smooth, flush margins, the correction of malocclusion, the removal of all calcareous deposits, polishing, the instruction in the home care of the mouth, may all be made prophylactic if properly done.

The Service of the Dental Hygienist.— The dental hygienist must regard herself as the channel through which the knowledge of prevention that the dental profession has acquired is to be disseminated. The greatest service she can perform is the slow and painstaking education of the public in mouth hygiene and allied branches of general hygiene. The education and training of dental hygienists does not aim to produce mechanical operators. An unlimited field of educational and preventive service is open to the dental hygienist who regards herself primarily as a hygienist and educator, and secondarily as a prophylactic operator.

The dental prophylactic operation of the dental hygienist is chiefly concerned with the exposed surfaces of the teeth, the necks of the teeth directly under the free margin of the gums, and the gum tissue itself. It must always be borne in mind that the aim of the dental hygienist is to secure extreme cleanliness of the mouth in an effort to starve bacteria and render them inert, and it is to this end that the coöperation of the patient must be secured.

It will be found that the average mouth presents an unsanitary condition that encourages the propagation of millions of microörganisms, and is a menace to the health of the patient. It is the duty of the hygienist to be kind in her criticism to such a patient, for in most cases the individual is not responsible for this deplorable condition. The ignorance of the patient regarding the proper care of the mouth, and the careless operative work of many dentists is usually responsible. It will be found that the great majority of patients are eager to learn the correct care of the mouth, and follow instruction faithfully when they are once enlightened. After these unsanitary mouths are seen to develop into healthy ones under prophylactic skill and instruction, the dental hygienist will realize that the service she may render to humanity is a very important one.

The procedure which should be adopted with a new patient may be divided into three parts: (1) The examination of the mouth; (2) the dental prophylactic treatment, and (3) the instruction of the patient in the home care of the mouth.

Examination of Adult Mouths.—The general condition of the teeth should first be noted. It will be found that the enamel surfaces are without luster and are covered with a pasty colorless film. The necks of the teeth are stained; calcareous deposits are seen on the lingual surfaces of the lower incisors and the buccal surfaces of the upper molars. All of these conditions can be corrected by the hygienist, but she is dependent upon the aid of the dentist to remedy the unsanitary construction of fillings, crowns and bridges. At this point all conditions of the teeth which the hygienist believes require the attention and coöperation of the dentist should be recorded upon a chart. This will include any decayed surfaces which she may note, as well as cough fillings or margins of fillings that are extended beyond the tooth surface and retain food débris. It will be necessary for the dentist to carefully grind and polish all such fillings in order that the desired

results may be obtained from the prophylactic treatments. A record should be made of fillings in the approximal surfaces if there is sufficient space to permit of food packing down between the teeth to injure or inflame the gum tissue. New fillings with proper contact points are frequently needed to remedy this condition.

If there are gold crowns or banded crowns that do not fit tightly to the tooth or root and that will permit the end of the explorer to pass between the root and the band or crown, it may be taken for granted that such a space is filled with decomposing food and is an ideal haven for bacteria. The odor arising from such crowns after their removal makes one realize the necessity for tight-fitting bands and flush joint operations. Hygienists will come to loathe the average gold crown and will use their influence against their insertion. Many of them are sources of systemic infection and nearly all will destroy the pericementum around the tooth, and result in the eventual loss of the tooth. Such dentistry is a serious menace to public health and has undoubtedly been the cause of many severe illnesses that have resulted even in death. If an ill-fitting gold crown is placed over a tooth containing a live pulp, it is but a question of time when the bacteria and the poisons generated by the decomposing process of the food débris lodging in the space under the crown where the cement has disintegrated and washed away, will penetrate the dentin and infect and destroy the pulp. Apical infections from teeth carrying gold crowns are common. It would be far better for the patient who could not afford to have the work done properly, to have such teeth extracted. Ill-fitting bridges so constructed that it is impossible to properly remove the food with the brush and washes will badly hamper work for mouth hygiene.

It is not necessary to know the details of the work of construction of crowns or bridges or of fillings, but it is necessary to know what constitutes good dentistry and sanitary construction. A small pimple on the gum, termed by the layman gum-boil, is in reality a fistula opening from an alveolar abscess. The attention of the dentist should be called to these fistulæ.

The gum tissue should now be examined. The term congested gums is applied to enlarged capillaries, engorged with blood and having a sluggish circulation. External irritation from lack of use and function in the mastication of proper foods is usually the cause for this congestion. The deep red color is due chiefly to the sluggish flow of blood laden with carbon dioxid. Perfect metabolism is not taking place in the cells of this tissue and the waste products are not being carried away with sufficient rapidity. Any local irritant on the surface or border of the gums will produce this congestion, and the mouths are rare that do not contain a number of congested surfaces.

In the mouths of children this condition is also produced by the sharp edges of decayed or broken-down teeth, temporary and permanent, and sufficient blood and serum ooze from these blood-engorged areas to form an excellent culture medium for pathogenic bacteria.

Every organism has its vulnerable or vital area which if sufficiently injured will eventually cause its death. The tooth is no exception to this rule. Its vulnerable point is the border of the peridental membrane directly beneath the gingival margin of the gum around the neck of the tooth, and this must be carefully safeguarded. This membrane forms the most vital part of the foundational structure of the tooth. Upon its health and resistance depend the function and life of the whole tooth. If it becomes injured, irritated or infected at its border and the lesion or infection is neglected, the membrane dies at this point, and in dying it causes the death and absorption of a similar area of the alveolar process which was in apposition to the affected membrane. This means a space or so-called pocket under the margin of the gum where food débris can find lodgement and where bacteria, well out of the currents of the saliva which flow freely around the teeth, can hold a tenable position.

The rapidity of the progress of death and absorption is dependent upon the resistant force contained within the cells of the membrane and upon the virulency of the attacking microörganisms. In childhood this membrane is thick and highly vascular and can resist almost any invasion of bacteria even when wounded, if not too seriously. In adult life it gradually becomes thinner, its blood supply is lessened, and as age advances the cells lose the high resistant force that they possessed in youth; and if the person is in what we call a run-down condition physically, from improper feeding of the body, unclean environments, harmful habits, excesses, or from any cause that will disturb the proper metabolism of the tissue by disturbing the nutritive or the nervous systems, the resistant force is still further lowered and the peridental membrane and the surrounding supporting tissues of the tooth become easy prey to the invading bacterial host. Although it will be possible to raise the resistance of this membrane again by prophylactic treatment and training of the patient in the proper methods of artificial stimulation, it can readily be seen that it is far more desirable to prevent the original disturbance at the neck of the tooth and save the patient the surgical treatment necessary in the hands of the dentist in order to get control of this much-dreaded and serious condition of absorption and infection of the supporting tissues of the root of the tooth. It must always be borne in mind that the most important part of the tooth is the root and any irritation of the gingival border of the gum, especially in adult life, is a menace to that tooth which is in closest proximity to the point of irritation.

Before operating in the mouth of a new patient the hygienist should make sure that the patient has removed all of the food débris from the teeth that it is possible to remove with the tooth-brush, floss silk and mouth wash. It is never the duty of the hygienist to operate in a mouth that contains food débris. For her own self-respect and for the dignity of her calling, she should make it an absolute rule never to start an operation of prophylaxis when the patient has failed to clean

his teeth of food débris before coming to her department. It is never her duty to remove food débris excepting the small quantities that roughened surfaces have made it impossible for the patient to remove. These cases will require some diplomacy on her part, for she must realize that the patient has not intentionally insulted her by presenting such an unclean mouth. It is merely that he has never been taught better. For years dentists have consented without remonstrance to operate in the mouths from which the food has not been removed from between the teeth, and it will be one of the missions of the hygienist toward the uplift of the dental profession to teach patients that they must not present themselves for any dental service whatsoever unless their teeth have been thoroughly brushed and flossed. She should be kind and considerate in the handling of such cases, and explain to the patient that there is danger of infecting the gum tissues if the instruments are used around the necks of the teeth where there is decomposing food, and that, in order to obviate any such danger it will be necessary for him to step to the bowl and thoroughly brush and rinse his mouth before the operation.

A stock of tooth-brushes should be a part of the equipment of every dental office and should be charged up against the expense of dental supplies. The cost of the brushes if bought in quantities, amounts to but little when we consider their absolute necessity for instruction, and their use when needed under these conditions.

Patients soon learn the rules of an office and in a comparatively short time it will be a rare thing to be obliged to send a patient to the bowl to brush his teeth before the prophylactic treatment can be started. Much of the soreness of the gums after these treatments in the mouths of new patients is due to crowding some of this infected material under the gum margin with the instrument, and it follows that the cleaner the necks of the teeth are before instrumentation, the quicker will be the recovery of the congested gums after treatment.

The Prophylactic Treatment.—In considering the practical work of dental prophylaxis the operation in the mouth of the adult will be first described. With a pledget of cotton soaked with peroxide of hydrogen, the necks of the teeth and also the approximal surfaces should be bathed. The boiling of the peroxide will mechanically aid in loosening minute particles of food débris. After rinsing the mouth with warm water the teeth should be thoroughly sprayed on all their surfaces with compressed air and an atomizer. The air pressure should be at least twenty-five pounds, so that it may have enough force to blow the spray with sufficient force between the teeth to aid in this mechanical cleansing. It makes no difference what liquid is used in the atomizer if it is harmless and has a pleasant taste.

Surfaces of the Teeth.—It must be remembered that in this work hygienists are not to cross the border-line into surgery. The laws in all states prohibit surgical or medicinal treatment by any but graduate practitioners. Therefore the entire efforts of the hygienist are to be

confined to the exposed surfaces of the teeth and the area directly under the free margin of the gum.

The base of the crown of each tooth has four lines or boundaries. This is the entire field for the use of the instruments unless a root surface is exposed. It can be readily appreciated what a slow and painstaking piece of work it is to go over carefully each of these surfaces and remove all of the deposits of tartar. In the first treatments of neglected mouths the deposits are likely to be large and are usually found on all the surfaces at the necks of the teeth. It is impossible to remove all of these deposits at one sitting without subjecting the patient to an unnecessary strain. The large deposits may be broken down and scaled off and many of the smaller nodules can be removed, but it is quite impossible to be really thorough in the first treatment. Again, it is unwise to subject patients to a too strenuous session, for if they are timid, they are apt to become discouraged by the long and tedious sitting. It is far better to arrange two sittings of an hour and a quarter to an hour and a half each than one of two hours and a half. If the appointment is made for two hours, the balance of the time may be spent in polishing and in instruction of the home care of the mouth.

The subject of calcareous deposits has been so thoroughly covered by Dr. Kirk, that it is unnecessary to go into it very deeply, but attention should be called to the irritating action they display in their porousness in absorbing liquefied débris, therefore forming an excellent retainer for bacteria. It is absolutely essential for the health of the gums and the roots of the teeth that all such deposits be removed at frequent periods. The time may come when people may be induced to eat the proper foods in proper quantities, then this deposit will be greatly lessened, but until this goal of good sense is gradually reached, artificial care of the mouth by prophylactic treatments will have to be resorted to.

Much of the evil from the forming of serumal deposits in the subgingival space can be obviated by eliminating the congested condition of the capillary circulation found in the gum tissue of the mouth of the average adult. But the mouths are indeed rare in which no new deposits can be found under the gingival border after a period of two months.

System for Instrumentation.—In order to perform a prophylactic operation intelligently one must work by system, and the instrumentation as well as the polishing must have a definite starting-point in the mouth and should always proceed in the same given direction over the surfaces of the teeth in the case of every patient. This is necessary for thoroughness and also in case of interruption, for if one will but note mentally the last tooth being worked upon before leaving the chair, the chain will remain unbroken upon resuming. It matters little what system is finally adopted, but the one here suggested is advocated because it has proved very practical.

Lower Jaw.—Beginning on the lingual surface of the right lower last molar at the gingival line, distolingual angle, instrumentation proceeds mesially until the lingual border of the left lower central is reached. The same direction is now followed but the line of operation becomes distal on the left side, still keeping on the lingual surface until the distolingual angle of the left lower last molar is reached.

Again starting on the distobuccal angle of the left lower last molar, the instrumentation proceeds buccally and mesially until the left lateral is reached, where from this point the operation continues on the same surface to the distobuccal angle of the right lower last molar.

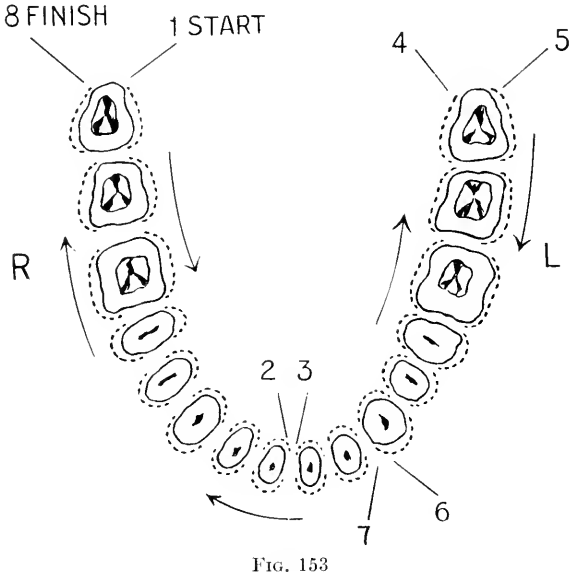


FIG. 153

The following cuts are taken from Plate VI of the *American System of Dentistry*, and will, by the dotted lines and arrows, better illustrate the directions followed as just described. Fig. 153 represents the teeth of the lower jaw with crowns excised at the gingival border. These cuts will illustrate the lines to be followed and field of operation to be covered by the dental hygienist with the instruments.

As shown by the dotted lines in Fig. 153, this first use of the instruments on the lower teeth covers only the lingual and buccal surfaces. By working along on the same surfaces of the teeth on the same jaw, considerable time may be saved by not having to change instruments every moment or two, as one instrument frequently will adapt itself to eight teeth before it will be found necessary to change.

After the deposits have been removed from the lingual and buccal surfaces, attention is given to the distal surfaces. Once more beginning on the distal surface of the right lower third molar, the distal

surface of the right lower molars, bicuspids and cuspid are carefully scraped. Next the distal surfaces of the left lower cuspid, bicuspids and molars, as illustrated in Fig. 154. One instrument will usually adapt itself to these surfaces. Next the mesial surfaces of the right

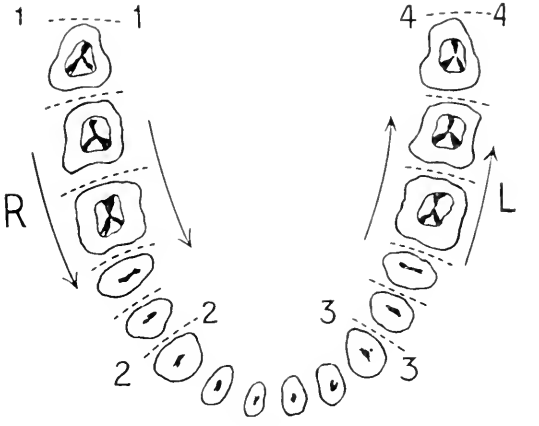


FIG. 154

lower molars, bicuspids and cuspid, then the mesial surfaces of the left lower cuspid, bicuspids and molars. These surfaces, too, may usually be covered with one instrument. Lastly, the approximal surfaces of the lower incisors, which may be covered with two instruments (Fig. 155).

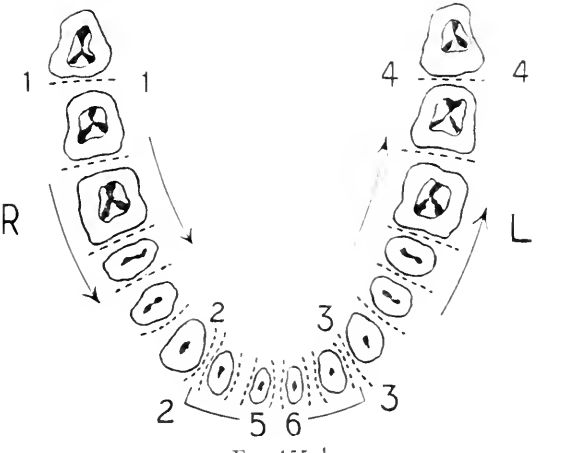


FIG. 155

Upper Jaw.—On the upper jaw at the point corresponding with that where work was first started on the lower jaw, the distolingual angle of the right upper third molar, the lingual surfaces of the superior set

are cleaned of all calcareous deposits, working mesially until the left central is reached, then distally to the left third molar. Again start-

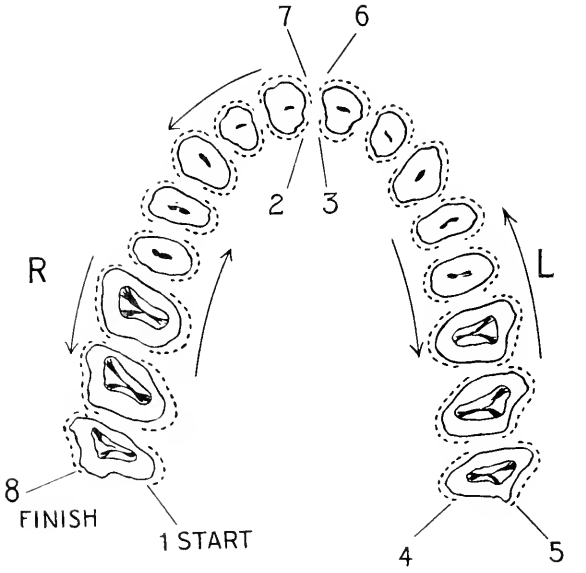


Fig. 156

ing at the distobuccal angle of the left upper third molar the buccal surfaces are gone over, working mesially to the right central then

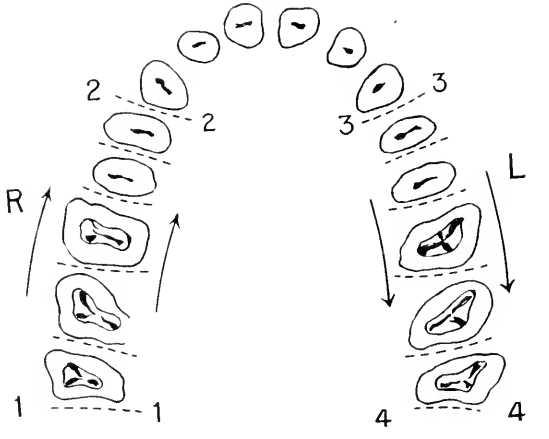


Fig. 157

distally to the right third molar (Fig. 156). Now beginning at the right third molar, the distal surfaces of the right molars, bicuspids and

cuspids are scraped. Next the distal surfaces of the left cuspid, bicuspids and molars (Fig. 157). In the same order the mesial surfaces are gone over, leaving the approximal surfaces of laterals and centrals until the last (Fig. 158).

If this briefly outlined system is followed there will be but little chance that the deposits may escape the play of the instruments.

There is nothing that instils a greater confidence in the operator, in the mind of the patient, than the gentle touch of his hand and the instruments. The very first requisite is to try to develop a firm yet gentle touch. In handling the lips, the cheek, the tongue, the motions should be slow enough and deliberate enough to insure gentleness. Such precautions in self-training soon improve the technic in handling the instruments, and it is much the better fault to be over-gentle and a little less thorough to begin with than to be heavy-handed,

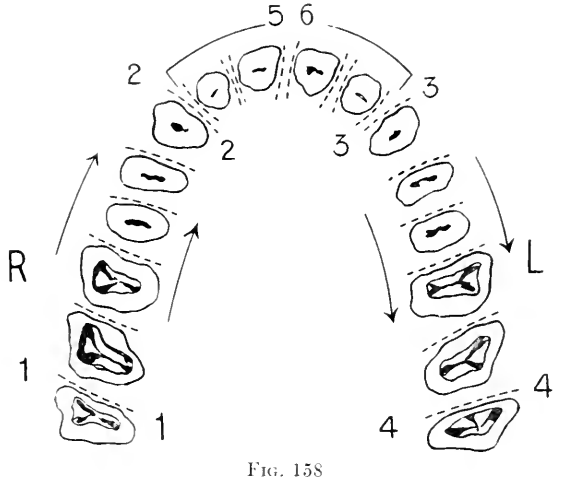


FIG. 158

rough and overstrenuous with the instruments. There is no better application of the golden rule than in dentistry, and the operator who masters a fine sense of touch and constantly keeps in mind a sympathetic consideration for his patient, has conquered much that is productive of success.

One of the most perplexing and yet one of the most essential things to master at the start is the proper handling and use of the mouth mirror. The mouth mirror is especially essential in operating on the lingual surfaces of the upper teeth and can also be used to advantage in holding the tongue away from the lingual surfaces of the lower teeth.

As the motion reflected in the mirror is reversed from that of direct observation, it is puzzling at first to place the instrument properly, but a little practice will soon obviate the difficulty. The Dunn cheek

distender is used to expose the buccal surfaces of the teeth, both in instrumentation and polishing, and its use adds much to ease of vision and access to these surfaces.

The Four Motions.—In instrumentation, as well as in polishing, there are four distinct motions. These may be termed digital, wrist, rotary or forearm and rigid arm. In acquiring these movements the fulcrum point of the hand in relation to the hold of the instrument is the determining factor. If the digital motion is to be used, the instrument or polisher is grasped as illustrated in Fig. 159. The end of the right thumb is the fulcrum-point or rest. This position permits of a perfect control of the instrument and allows a play of the instrument in either a push or a pull stroke. This motion is used particularly on the teeth of the upper jaw. It might be well to state here that no instrument should be used in the mouth unless the hand is first braced

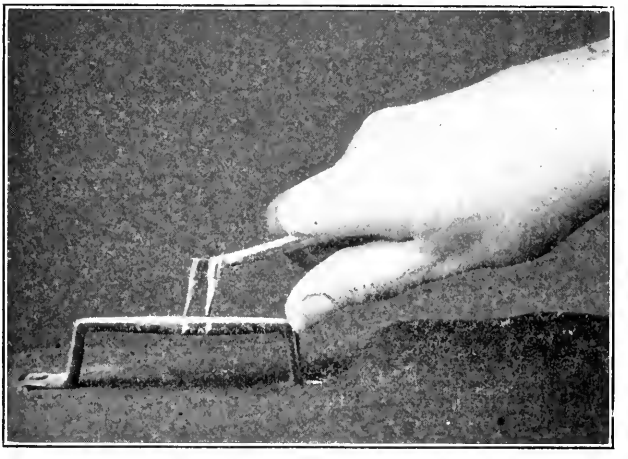


Fig. 159

by a suitable rest for one or more of the fingers of the hand holding the instrument. No free-hand motion should be used. Such motions would be almost sure to invite a slip of the instrument and result in laceration of the gum tissue. The wrist motion is acquired by holding the instrument as illustrated in Fig. 160, using the end of the second or third fingers as a fulcrum. This motion may be used in various parts of the mouth, especially on the lingual surfaces of the molars and bicuspids, but it is not as effective for general use as the forearm or rotary movements. The forearm or rotary motion is used on both the upper and lower jaws and usually the end of the third finger serves as a fulcrum, although that of the second finger can sometimes be used. This motion is produced by holding the muscles quite rigid, permitting the radius to rotate around the ulna bone in a limited area. After a little practice this motion permits of a rapidity of work with the

instrument under perfect control, and to master this stroke is to master much of the technic of instrumentation and polishing.

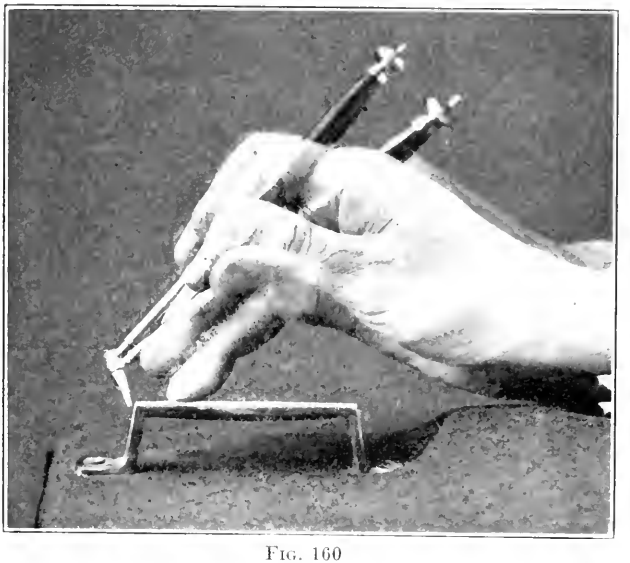


FIG. 160

Fig. 161 illustrates the position of the hand when using the rotary motion.

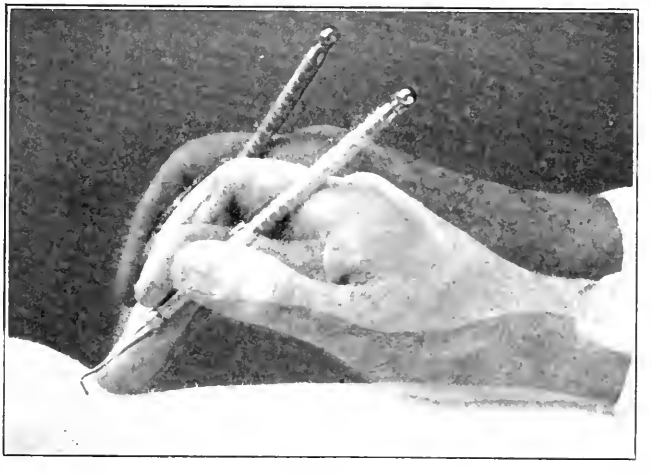


FIG. 161

The rigid-arm motion is used for polishing nearly all of the labial and buccal surfaces of the teeth, both upper and lower, and for the lingual surfaces of the molars and bicuspids. The rest is usually found

by using the side of the second joint of the right thumb on the chin or the second joint of the third or fourth finger as illustrated in Fig. 162.

The muscles of the whole arm are made fairly tense and the arm is made to travel forward and backward in a short, limited area. All of these motions should be practised over and over again on manikins before being tried in the mouth. They are not easy to master and the muscles must be trained by repeated practice.

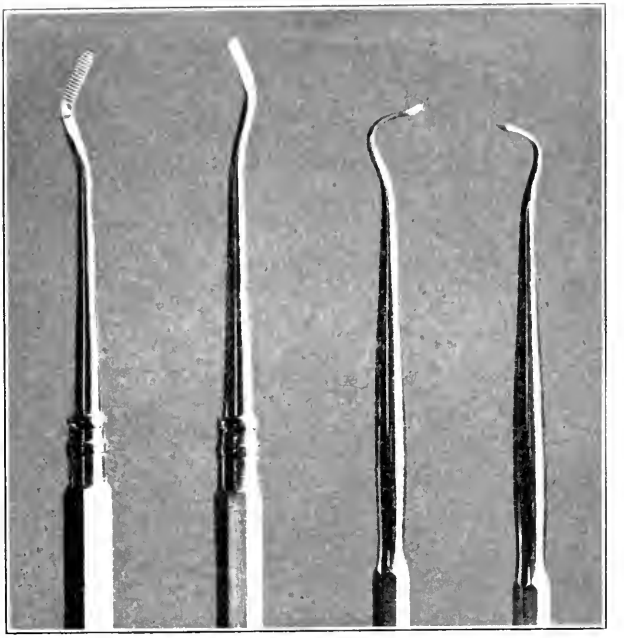
In the removal of tartar around the necks of the teeth, there are two strokes that may be utilized, a push stroke and a pull stroke. Which to use is determined in a great measure upon the quantity or bulk of the deposit and also upon the tenacity with which it may cling to the tooth surface. In scaling off pieces of hard deposits, large or small, the draw or pull stroke will be found most effective. The instrument is carefully carried a little below the gingival border of the gum and hooked securely over the shoulder of the deposit. Then with the

Fig. 162

hand properly braced, the instrument is firmly drawn toward the masticating surface or cutting edge of the tooth—a second digital motion (Fig. 162). When the deposits are small and fairly soft, a short, pushing stroke will be more effective.

Instruments.—Before the handling of the instruments is described in detail a set of scalers will be considered that should be sufficient for the beginner for all prophylactic work upon the necks and crowns of the teeth. These include eleven instruments and may be described as follows:

Fig. 163. The two small curved instruments with the spoon-like ends are known as Nos 17 and 18 of the set of Darby-Perry excavators. They are curved in opposite directions to each other and are paired as rights and lefts. Dr. C. W. Strang, of Bridgeport, Ct., suggested their use. Nos. 5 and 6 belong to the D. D. Smith set and are made by J. W. Ivory, of Philadelphia. Fig. 164, Nos. 13 and 14,



5 6 18 17

FIG. 163

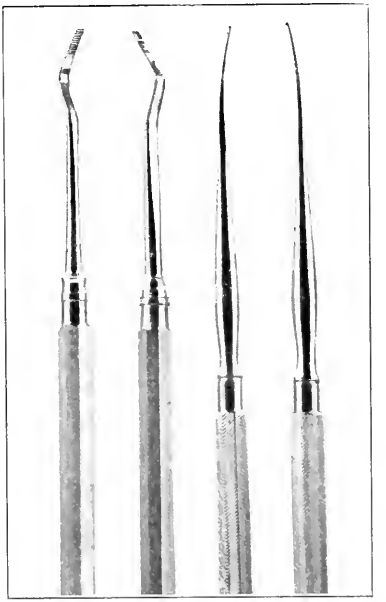


FIG. 164

were designed by Dr. E. S. Gaylord, of New Haven, Ct., and are a part of the Smith set, and are also made by J. W. Ivory. Nos. 3 and 4 are from the Harlan set of scalers made by the S. S. White Company.

Fig. 165 illustrates the S. S. White scalers Nos. 33 and 34 and No. 3 sickle-shaped, which are all used for the removal of heavy deposits by the pull or digital stroke.

The use of No. 3 sickle-shaped, and Nos. 33 and 34 is especially indicated in the first treatment of mouths where the deposits have accumulated for some time. For subsequent treatments the smaller instruments mentioned should meet the requirements of the dental

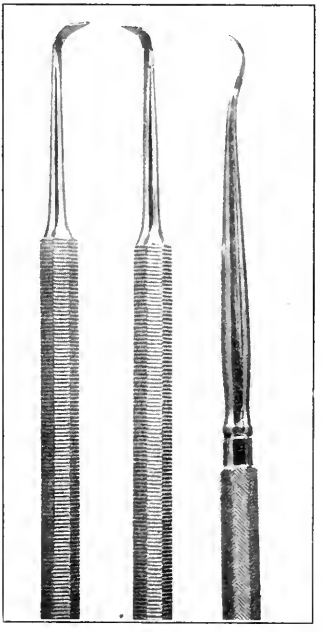


Fig. 165

hygienist. At this point it must be distinctly understood that the cleaning of teeth bears the same relationship to dental prophylaxis as plowing does to agriculture. The plowing is essential before the science of agriculture can be applied. The removal of the heavy deposits, large accretions and accumulations of stains and plaques is essential before the real science of prevention can be applied. A true prophylactic treatment must be designed to aid in the prevention, not only of dental caries, but of any of the departures from the normal of the supporting tissues of the teeth. It must constitute, then, the painstaking, frequent and systematic removal from the exposed surfaces of every tooth the granular deposits, the accretions and incipient plaques by instruments and hand polishers.

INSTRUMENTATION.

Lower Jaw.—Assuming that the deposits are not unusual in quantity and are reasonably easy to remove, the adaptation of these instruments will be described, proceeding as in Fig. 153.

Starting at the distolingual angle of the right lower last molar, No. 18 of the Darby-Perry excavators is selected and held at the angle shown in Fig. 166. The stroke used is a short downward push, and a wrist motion is used with the blade held at nearly a right angle with the tooth. On the downward stroke, the back of the blade with its smooth, blunt surface will strike the gingival border of the gum and

FIG. 166

prevent the cutting edge of the instrument from traveling far enough to injure the subgingival tissues. This short stroke is rapidly repeated, the operator making a wave-like motion of the instrument, gradually moving it forward, mesially, on the lingual surface of the molar until the mesiolingual angle is turned, and using the mouth mirror with the left hand to keep the tongue out of the way. The instrument is now transferred to the next molar and the operation is repeated. This is continued with the same instrument until the left lower central is reached, from No. 1 to No. 2 in Fig. 153. The mate to this instrument, No. 17, is now substituted and the operator, starting on the lingual surface of the left central, Fig. 167, and using a rotary stroke, continues until the distolingual angle of the left lower last molar is reached,

Fig. 168 or from No. 3 to No. 4 in Fig. 153. These small instruments greatly magnify the sense of touch, so that each small deposit is readily felt, whereas a larger instrument might pass it by.

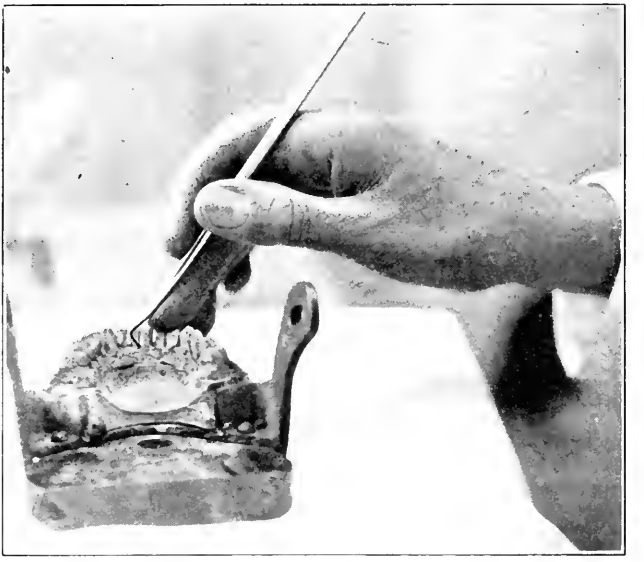


Fig. 167

Fig. 168

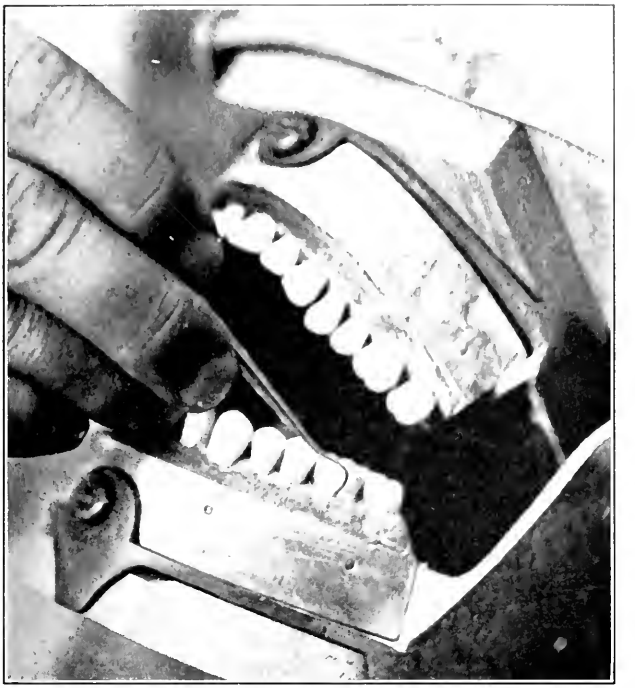


FIG. 169

FIG. 170

Again starting at the distobuccal angle of the left last molar with instrument No. 18, Fig. 169, this short, pushing stroke with a wrist motion is used until the left lateral is reached. From No. 5 to No. 6 in Fig. 153. Although the same instrument can be used effectively on the labial surfaces of the incisors, it will be found advantageous to change for its mate, No. 17, and, leaning slightly in front of the patient, brace the hand by the third finger on the masticating surface of the first bicuspid (Fig. 170), using a wrist motion which permits of a careful handling of the festoons of the gums of the lower incisors. After the labial surface of the left lateral is finished, the hand is moved

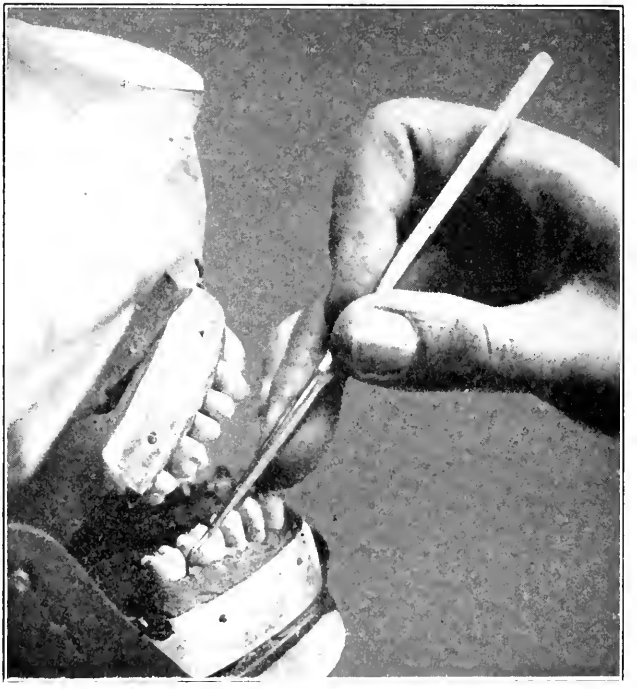


Fig. 171

forward to engage the next tooth. At the right cuspid the rotary stroke is now adopted and continued to the last molar. Fig. 171 or from No. 7 to No. 8 in Fig. 153. The finger rests for the work just described are found on the masticating surfaces of the bicuspids or on the cutting edge of the cuspid or incisors.

The base of each tooth has four lines. Two of these lines have now been covered, and there remains the approximal surfaces or the distal and mesial lines. No. 13 is an instrument with the end bent at an angle of forty-five degrees, having a long blade with a file-cut surface, the numerous small blades of which are very effective in removing

the small deposits. This instrument should be used chiefly with a pull stroke, starting at No. 1, in Fig. 154, which is the distal sur-

Fig. 172

Fig. 173

face of the right lower last molar, as shown in Fig. 172. The distal surface of the last molar being free, the blade is carefully passed

down under the gum line until the sense of touch determines the bottom of the subgingival space. The blade is then brought tight against the tooth surface and pulled upward. An eighth to a quarter of an inch play of the blade is sufficient to dislodge the deposits. This stroke is rapidly repeated across the back of the tooth. In adapting this instrument to the distal surface of the second molar the blade is inserted sidewise from the buccal surface (Fig. 173), and with a short push-and-pull stroke the instrument is worked between the teeth in order to cover the entire distal line. If the teeth are so shaped and are so close together that they will not permit the blade to pass between them, then the instrument should be inserted also from the lingual surface. and in this way that part of the distal line that was inaccessible from

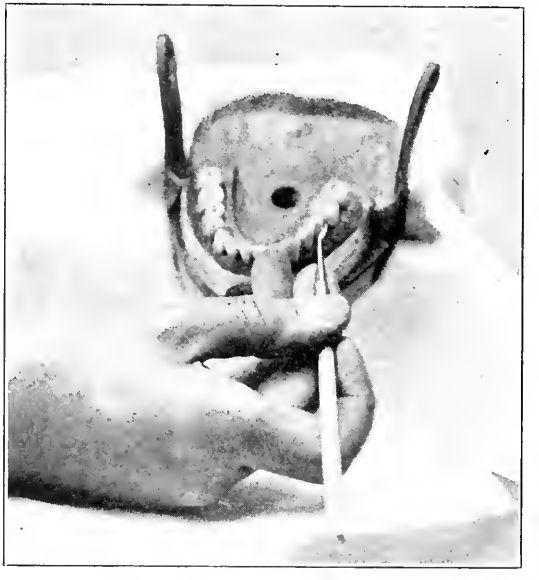


Fig. 174

the buccal surface is covered. With the same instrument the distal surfaces of the teeth may be scaled to the incisors, or from No. 1 to No. 2, in Fig. 154. Again, with the same instrument, the operator should start on the distal surface of the left cuspid, and entering from the buccal side, proceed on to the last molar, or from No. 3 to No. 4, in Fig. 154. The procedure for the mesial surfaces is the same as described for the distal, except that the instrument used is No. 14, and one position is illustrated as in Fig. 174. Both push and pull strokes are employed. The lower incisors are scaled on their approximal surfaces by the bayonet-shaped Smith scalers, Nos. 5 and 6, from No. 5 to No. 6 of Fig. 155, which shows this area. Fig. 175 illustrates the adaptation of these instruments.

Upper Jaw.— On the upper jaw, at the right distolingual angle of the last molar, instrument No. 17 is placed at nearly a right angle with the tooth and, with the hand braced on the top of the left lower lateral and cuspid teeth, using the third finger as fulcrum (Fig. 176), a wrist

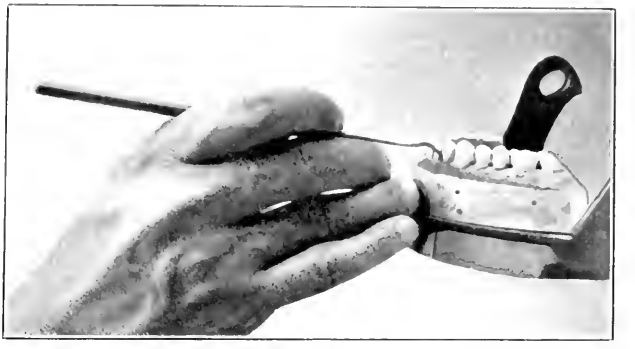


FIG. 175

and digital motion is employed, the instrument being made to travel forward with a short up-and-down, push-and-pull stroke combined, perhaps better described as a waving stroke. The fulcrum-point is maintained, the instrument being drawn in or shortened as the incisors are approached. When the left central is reached (Fig. 156), instrument No. 18 is substituted, the second finger used as a fulcrum

FIG. 176

on the cutting edge of the right upper cuspid (Fig. 177) and the lingual surfaces of the upper teeth of the left side are gone over with a wrist and digital motion. This fulcrum-point is maintained and the instrument advanced in length with the thumb and first finger (Fig. 178).

Again starting at the distobuccal angle of the left upper third molar, the third finger is placed slightly back of the cutting edge of the right upper lateral and central while the second finger rests on the cutting edge of the left upper central (Fig. 179). This position can be held until the left lateral is reached, the motion being wrist and digital. Shifting the fulcrum-point to the end of the third finger on the edge of the right upper cuspid, the labial surfaces of the left central and lateral may be scaled with the same instrument. With the hand resting against the

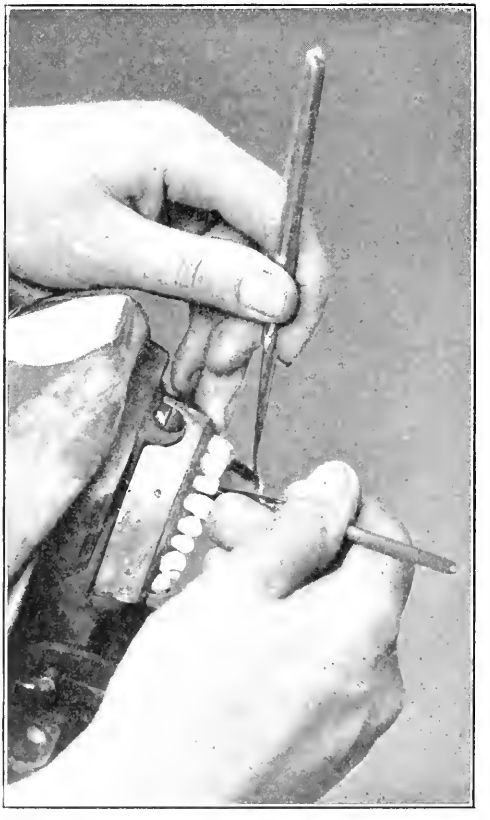


Fig. 177

chin just below the lower lip, and the third joint of the little finger serving as a fulcrum, with instrument No. 18, the right central and from there back to and including the third molar is scaled, using the digital motion, as in Fig. 180.

The lingual as well as the labial and buccal surfaces, having been covered, No. 13 is used for the distal surfaces (Fig. 157) of all the upper teeth excepting the incisors. For the molars, bicuspids and cuspids of the upper jaw the description of the use of this instrument for those

on the lower jaw may be applied, the hand rest being found chiefly on the cutting edge of the lower incisors, the end of the third finger

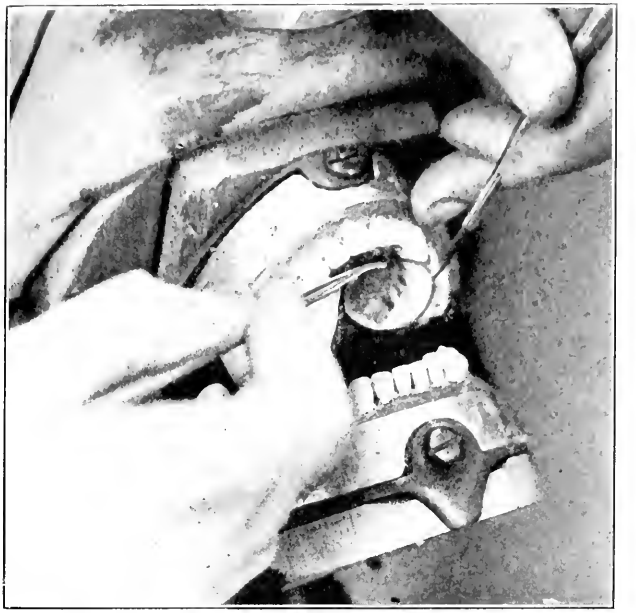


FIG. 178

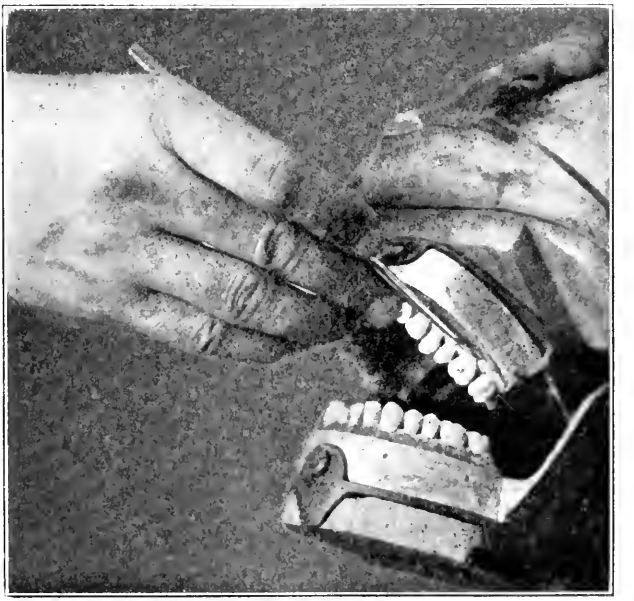


FIG. 179

serving for fulcrum. No. 14, Fig. 158, is used in a similar manner with the hand rests the same as for No. 13. Nos. 5 and 6 are best adapted

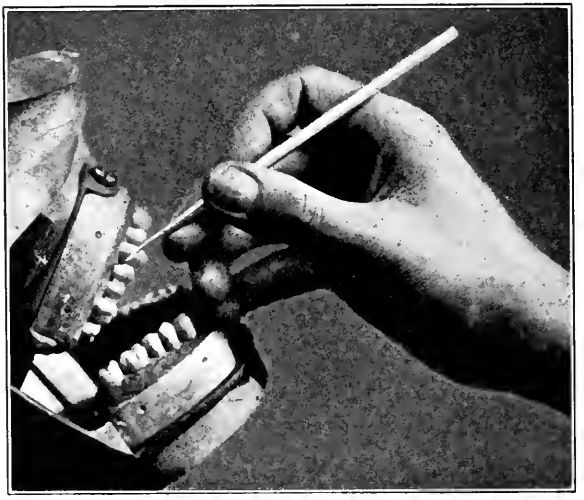


FIG. 180

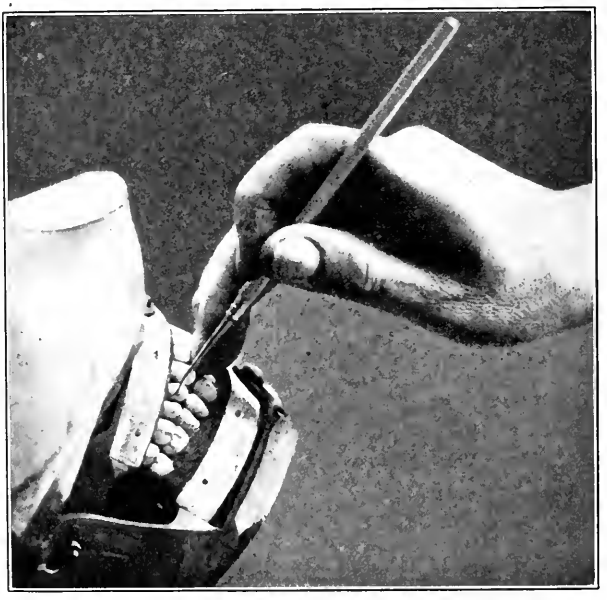


FIG. 181

for the approximal surfaces of the incisors, their use at this point being too self-evident to need explanation.

Even with this detailed description, much will be found lacking to the beginner, but after a little practice on the manikin the hand will soon adjust itself to the proper rests to secure the greatest efficiency and control of the instrument.

In removing the heavy deposits the sickle-shaped instrument, No. 3, and scalers Nos. 33 and 34 will be found most useful. In skilful hands it is possible to scale roughly nearly all the surfaces of all the teeth with these instruments, the exception being the approximal surfaces. No. 3 is used with a draw or pull stroke and has the advantage of not being dangerous around the anterior teeth, for the point of the instrument as well as the side of the blade is inserted under the deposit and pulled directly upward on the lower teeth and downward on the upper teeth. But in the back of the mouth where its adaptation necessitates the drawing of the instrument forward under the border of the gingiva, the point is likely to slip and travel too deep into the subgingival space unless care is used. A firm hold on the instrument and a secure brace of the hand is absolutely essential. This sickle-shaped instrument is used almost entirely with a digital motion and the two principal positions are illustrated in Figs. 182 and 183. It is very difficult to scale the teeth thoroughly with this instrument, but the larger deposits having been removed at the first sitting, Nos. 17 and 18 can be used to advantage at the second and all subsequent treatments.

The Harlan instruments, Nos. 3 and 4, are also used with a draw stroke and are helpful in removing the small, hard, tenacious deposits under the free margin of the gums. They are adaptable in nearly all sections of the mouth and their use is usually self-suggestive. When these small deposits resist Nos. 17 and 18, especially on the bicuspids, cuspids and incisors, these Harlan instruments will be found very effective.

If uncertainty exists in the mind regarding the thorough removal of all deposits, an instrument known as an explorer carefully passed around the neck of the tooth under the gingivæ will readily detect any small deposits or uneven surfaces. The smaller the instrument, the more greatly is the sense of touch magnified. It is for this reason that the use of Nos. 17 and 18 is advised wherever practical.

There are two special features to be considered under instrumentation: First, the sensitiveness that is frequently found around the necks of the teeth, and second, the bleeding of the gingival borders of the gums. In adults where the lime deposits have been heavy, their removal will frequently cause much sensitiveness for a week or two, sometimes even longer, to heat and cold and to sweets and acids. The deposits have caused an absorption of the border of the alveolar process, the soft tissues and the cementum around the necks of the teeth, and when they are removed the interglobular spaces on the border between the dentin and the cementum are exposed, presenting an area that is highly sensitive to the touch of the instrument or polisher. It is frequently wise to inform the patient that he may expect the surfaces to

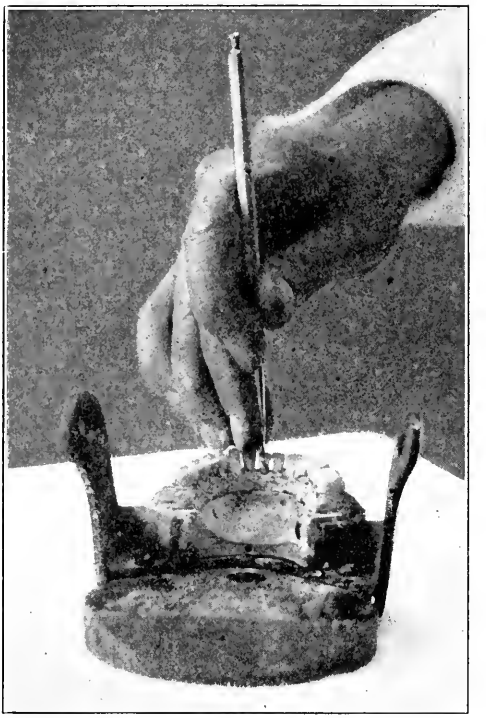


FIG. 182

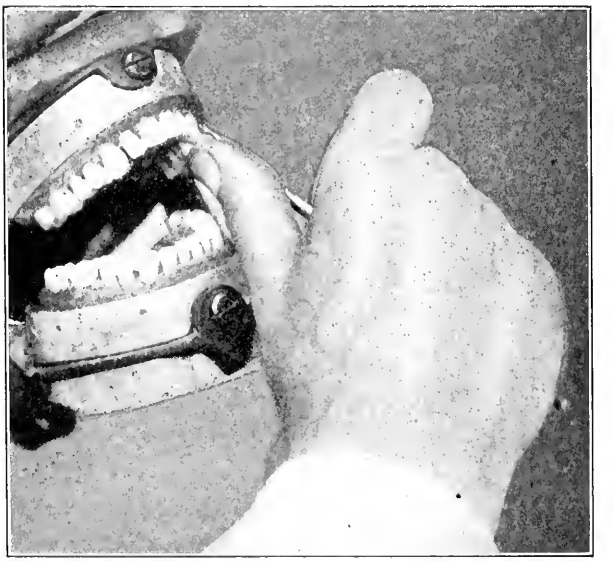


FIG. 183

be responsive to heat and cold for a short time, in order to allay any fears on his part. The deposits acting as a covering for these surfaces have protected them from external irritation, and the patients are apt to wonder why it is that their mouths are so much more sensitive than they were before the deposits were removed. Acids are especially irritating to these surfaces and the use of bicarbonate of soda, half a teaspoonful to a third of a glass of warm water, used as a mouth wash two or three times daily, will aid greatly in tiding over this short period of discomfort. If the soda can be used clear by dipping the finger in water, touching it to the soda and then rubbing it on these surfaces, it will all the more quickly neutralize any acid that may be irritating to this sensitive tissue. The thorough rubbing and polishing with the stick and pumice and the extreme cleanliness from the faithful use of the tooth-brush will soon bring these troublesome areas under control. The application of a 10 per cent. solution of nitrate of silver is sometimes advised, but if it is used, it should be followed by a thorough polishing with the stick and pumice.

The second feature, which will be considered briefly, is the bleeding of the gums during instrumentation. When the gums readily bleed there is congestion of the capillaries, and the more blood allowed to escape from the gingivæ, the sooner the congestion will be relieved. Instead of trying not to make the gums bleed, just the reverse course should be followed, although of course this does not mean that they should be lacerated or the tissue wounded. The bleeding process is produced by using the back or smooth surface of the blade of the instrument with pressure, and this is done while removing the lime deposits, and if there is a copious flow of blood from some of the approximal surfaces, it should be encouraged by rapid, gentle pressure strokes directly on the gingivæ. Healthy gums will not bleed during instrumentation, and when bleeding occurs enlarged and congested capillaries are sure to be found. No fear of causing injury to the gum tissue in causing a flow of blood need be felt as long as care is taken that the blade of the instrument does not cut the tissue. Frequently after such a treatment the gums will take on a color two shades lighter before the patient leaves the chair, and after a few days of stimulation with the tooth-brush it will be hard to recognize it as the deep red, congested tissue that it was at first.

POLISHING.

It is impossible to obtain the same results in prophylaxis with the use of the dental engine in polishing as may be secured with the hand polishers. This belief is based upon personal experience in faithfully trying out both methods, and is an accepted fact by all prophylactic workers who have become proficient with the hand polishers.

The object of this polishing process is threefold: First, the removal of stains, plaques and films or all soft accretions on the exposed surfaces of the teeth. Second, a polishing of the enamel surfaces and a

stimulating effect that seems to be imparted to the living tissue of the tooth itself by the vigorous massage. Third, the beneficial results obtained on the gingival borders of the gums by the slight bumping of the stick, causing light pressure and release which imparts a massage effect and aids greatly in producing a perfect flow of blood through the capillaries in the peripheral circulation. If a new case presents itself in which the teeth are very badly stained, it is perfectly reasonable, if desired, to use the dental engine for the first treatment to aid in cleaning off these stains from the enamel surfaces, but all subsequent treatments should be made with the hand polishers. An engine revolving at six or eight hundred revolutions a minute, with the rubber cup or buff charged with pumice, cuts too viciously and if used at each

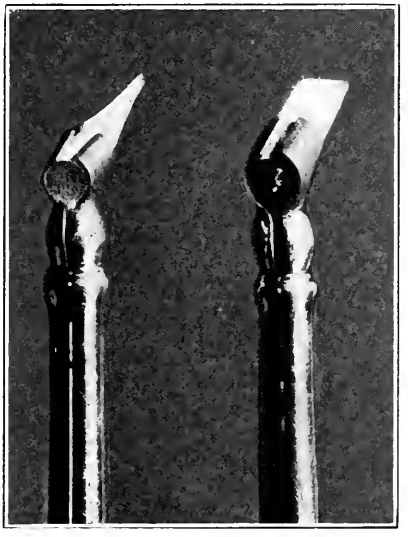


FIG. 184

prophylactic treatment, will in time affect the enamel and tooth structure at the necks of the teeth. With the dental engine all sense of touch is lost, and besides it is not as adaptable on the approximal surfaces or on the surfaces of the molars as the stick held in the hand. The gingival borders of the gums, in many mouths, have been badly wounded or damaged by the revolving cups or buffs in the dental engine, and if one hopes and expects to secure the best results in obtaining ideal health conditions of these tissues, one must become proficient with the hand polishers. Those who would advocate the dental engine are those who have failed to make themselves proficient with the hand polishers. There can be no choice if the latter is faithfully tried. There are a number of different woods that may be used for polishing, as cedar, maple, hard pine, etc., but the closest-grained wood and the

one best adapted for this purpose is orange wood. There are two sizes of sticks that may be had from the dental depots, known as large and small. The large size is cut about three quarters of an inch in length and one end is trimmed wedge-shaped. This stick is used on all the broad surfaces of the teeth excepting the masticating surfaces. The small stick is cut about the same length and one end is sharpened like the point of a lead-pencil. The smaller stick is used on the approximal surfaces and around the necks of the teeth where it is impossible to adapt the larger stick. In order to work with facility, two holders for the two sizes of sticks should be employed. Fig. 184 illustrates the Jack porte polishers with sticks in position.

As a slight abrasive and polish to be used with the sticks, the finest grade of pumice moistened with water will prove to be the most satisfactory. Although other polishing mediums are used with good results, it is doubtful if there is anything superior to fine pumice for this special

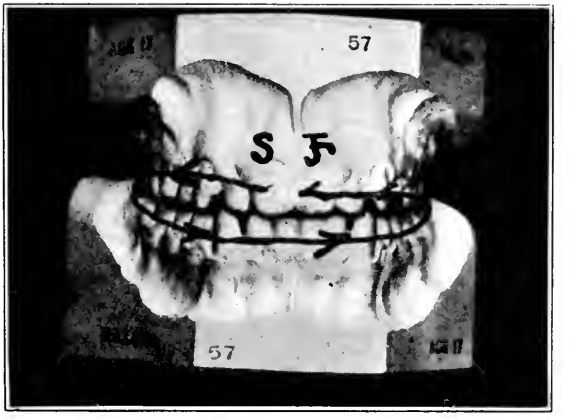


FIG. 185

work. A scant spoonful placed in a small porcelain dish, and wet sufficiently with water to be almost liquid, will make a mixture that can readily be picked up on the point of the wet stick and used in the mouth.

System for Polishing.—Just as a definite system is employed in going over the teeth with the instruments, so should a system for reaching all surfaces of the teeth with the polishers be followed.

The following system is very effective and its adoption is suggested, at least for beginners:

Starting on the labial surface of the right upper central with the large stick, the polishing progresses to the right lateral, then to the right cuspid and so on until the right last molar is reached. From this point start on the buccal surface of the right lower last molar and progress forward around the buccal and labial surfaces of all the lower teeth to the left lower last molar. Transferring the stick to the

buccal surface of the left upper last molar, the polishing is continued forward to the median line to and including the left upper central. All the labial and buccal surfaces have now been polished with the use of only the larger stick. Fig. 185 illustrates direction for polishing. Then starting on the lingual surface of the right lower last molar with the large stick, the polishing of the lingual surfaces proceeds forward to the incisors, then backward, or distally, to the lingual surface of the left lower last molar. Again beginning on the lingual surface of the left upper last molar, all of the lingual surfaces are covered, ending on the right upper last molar.

So far only the large stick has been used. Now with the pointed stick the same course should be followed over the teeth as has just been described, polishing in between the teeth as far as possible and

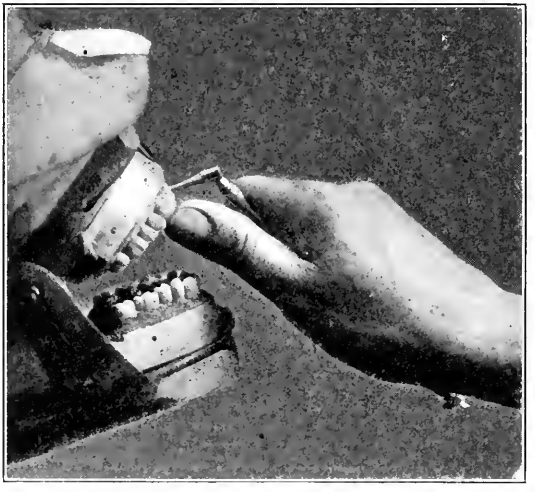


Fig. 186

rubbing the necks of the teeth under the free border of the gingivæ, keeping the edge of the stick sharp. When they become frayed or brush-like, they should be trimmed off with a pair of scissors, or if, after this, the edges are still too blunt, sharpened with a knife.

The polishing is confined almost entirely to two motions, the rigid-arm and the forearm or rotary. The one exception is the digital that should be used by beginners on the labial surfaces of the upper incisors.

In order to polish effectively pressure must be used. It is this one point of being able to apply pressure on all the surfaces while polishing that makes the operation difficult. This is noted especially in polishing the lingual surfaces of the molars and bicuspids. The proper hand rests are essential and also muscular practice of the motions used for this work.

Beginning on the labial surface of the right upper central with the

large stick, and using a digital motion, the stick is made to travel up and down the full length of the face of the tooth, rubbing the surface with both up and down strokes. The stick is allowed to bump the

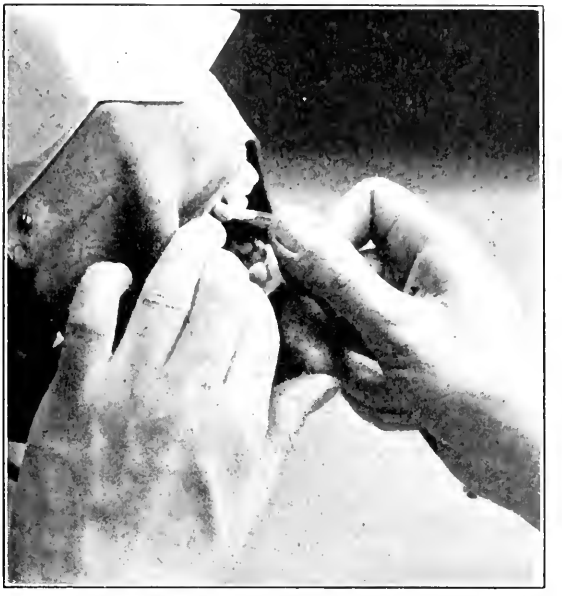


FIG. 187

FIG. 188

gum lightly but not hard enough to cause discomfort. Considerable pressure is used and the motion is rapid. Fig. 186 illustrates the position of the hand with the thumb rest on the cuspid for the digital

motion. When the right cuspid is reached the rigid-arm motion is employed, with the back of the second finger, between the second and third joints, resting on the side of the chin and the two bicuspids are rubbed and polished up and down or longitudinally, the right thumb pressing on the polisher at the end of the stick (Fig. 187). Now inserting the Dunn cheek distender, the buccal surfaces of the molars are rubbed crosswise, using the rotary motion and the same fulcrum position that was used with the cuspid and bicuspid, but the porte polisher is shifted in the hand and grasped as one would hold a pen-holder (Fig. 188). The end of the stick may be made to travel up and down part way on the approximal surfaces, but the principal motion for polishing is crosswise. The polishing of the right lower molars is the same as described for the upper molars. For the right lower

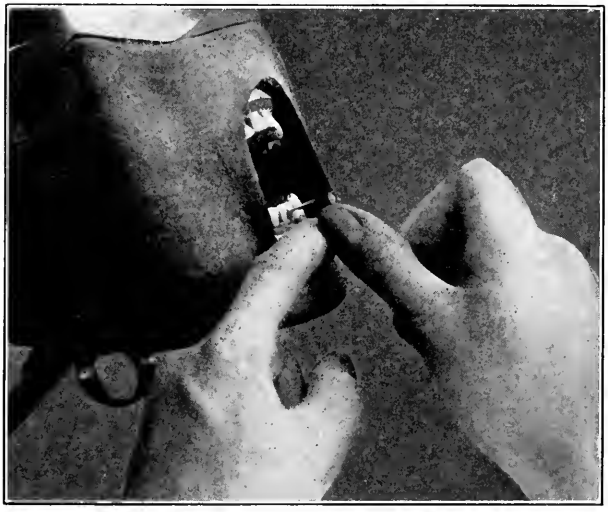


FIG. 189

cuspids and bicuspids, the same as for the upper. The first finger of the left hand now is placed across the inside of the lip to depress it and with the polisher grasped in the fist with right thumb resting on the left forefinger (Fig. 189), the lower incisors are polished. For the left cuspid and bicuspids the same position as for the right is used. In polishing the left lower and upper molars the back of the third finger becomes the fulcrum on the side of the chin and the polisher is grasped pen-holder fashion, as in Fig. 190, using the rigid-arm motion. The descriptions of the right cuspid and bicuspids, lateral and central, will apply to the left. It will be noted that, with the exception of the upper incisors and right molars, the motion used on all the outer surfaces of the teeth has been rigid-arm. That on the inner surfaces of both lower and upper is forearm or rotary. The difficulty met with is

FIG. 190

FIG. 191

that of producing pressure and at the same time retaining control and length of stroke. With the mouth mirror in the left hand to hold the tongue away, the backs of the third and fourth fingers are pressed against

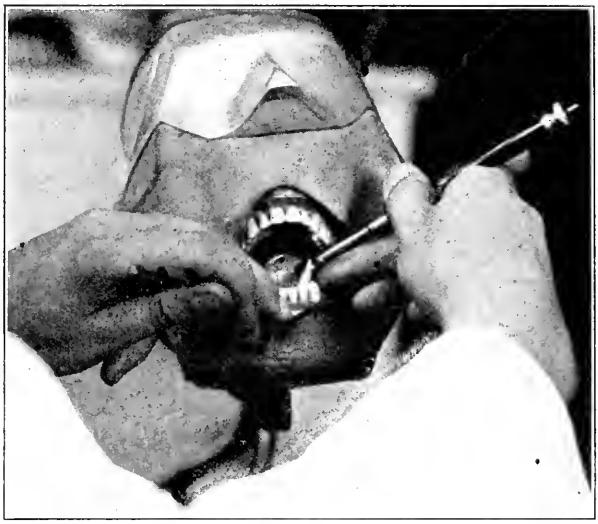


FIG. 192

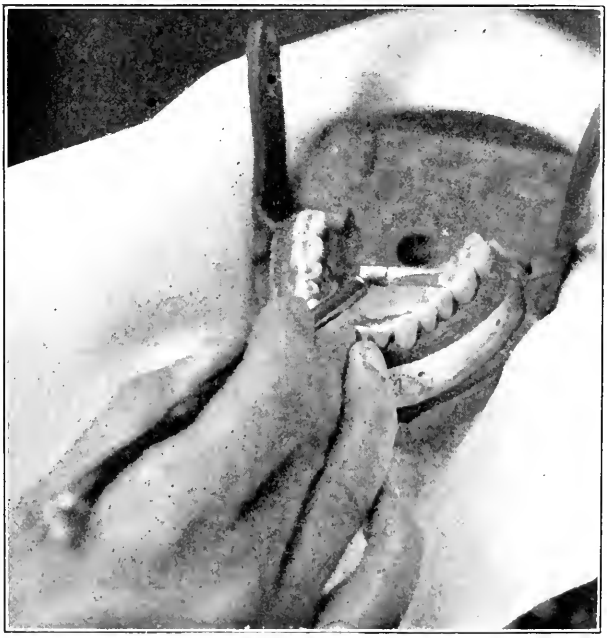


FIG. 193

the chin, and the polisher held as the pen-holder in a rigid grasp (Fig. 191), the stick is made to travel up and down on the inner surface of

FIG. 194

FIG. 195

the right lower molars, the edge of the stick pointing up and down with the long axis of the tooth. This polishing motion, it will be noted, is just the reverse from that used on the buccal surfaces. By shorten-

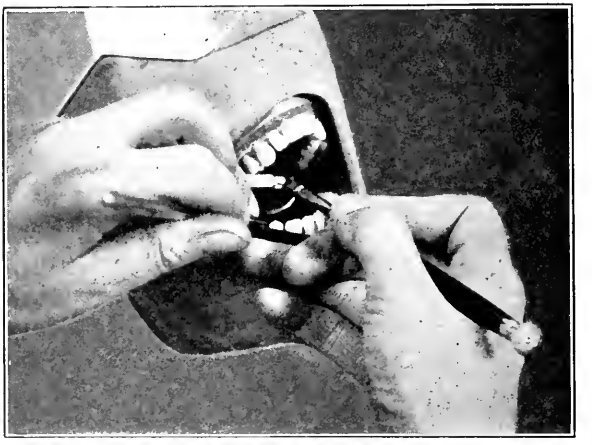


FIG. 196

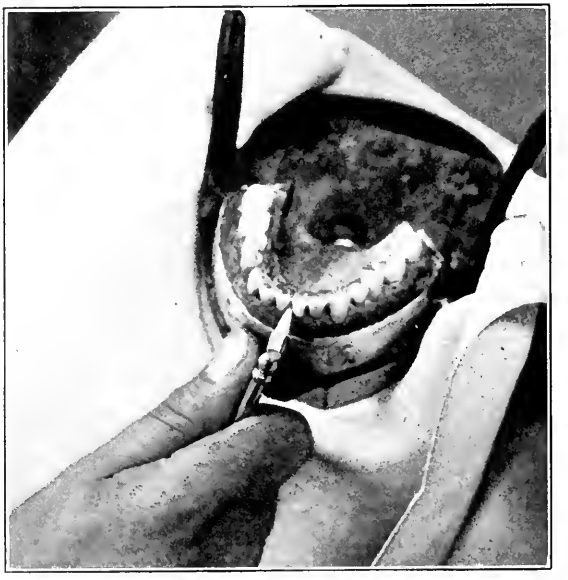


FIG. 197

ing the hold on the polisher the same position is used for polishing the bicuspids and cuspids.

Other adaptations of the stick will be found that are advantageous for these surfaces, such as using the side of the stick with an up-and-down stroke instead of its sharpened end.

By leaning forward in front of the patient the second finger is placed on the top of the left cuspid or bicuspid and with a rocking or rotary motion of the arm and stick the lower incisors are polished (Fig. 192). The left lower molars are polished with the same pen-holder grasp, using the second finger as a fulcrum on the right lower cuspid or lateral (Fig. 193). The mouth mirror can be used to good advantage while polishing the lingual surfaces by having the patient low enough. Starting on the lingual surface of the left upper last molar, the porte polisher is held like the pen-holder and, with the end of the third finger resting on the labial surface of the right lower cuspid (Fig. 194), the molars are rubbed chiefly up and down with the edge of the stick. Holding the same fulcrum-point, the grasp on the polisher is gradually shortened and the incisors are polished as shown in Fig. 195. The

FIG. 198

lingual surfaces of the right cuspid, bicuspids and molars are polished with the same hold of the polisher, the rest being found on the chin, using the back of the second joint of the third finger (Fig. 196). The motion used is mostly forearm or rotary.

All of the positions and fulcrum-points described for the large stick apply also to the small stick.

Where the gums between the teeth are congested, the side of the stick is pressed against them with a fast, quick stroke to encourage the bleeding. Care should be taken in the use of both sticks not to abrade the gingivæ, but the light pressure with the side of the stick against the gum margin will prove very beneficial (Fig. 197). When sensitive surfaces are found at the necks of the teeth, the pointed stick freely charged with pumice is applied with vigor and considerable pressure.

A thorough polishing of their surfaces will greatly aid in reducing the sensitiveness.

Floss Polishing.—After polishing with the sticks there still remain the contact points and an area on the approximal surfaces that have not been reached. By doubling a length of ligating silk, twisting it and dipping it in water and then in pumice, these surfaces may be polished quite effectually. When the teeth are very close together a single strand will be found sufficient, as this silk is larger in size than that sold for every-day flossing. Cutters' wide floss may also be used to advantage where the space will permit. When using the floss for polishing it should be passed between the contact points with care, so that it will not snap on the gum, drawn back and forth on the distal

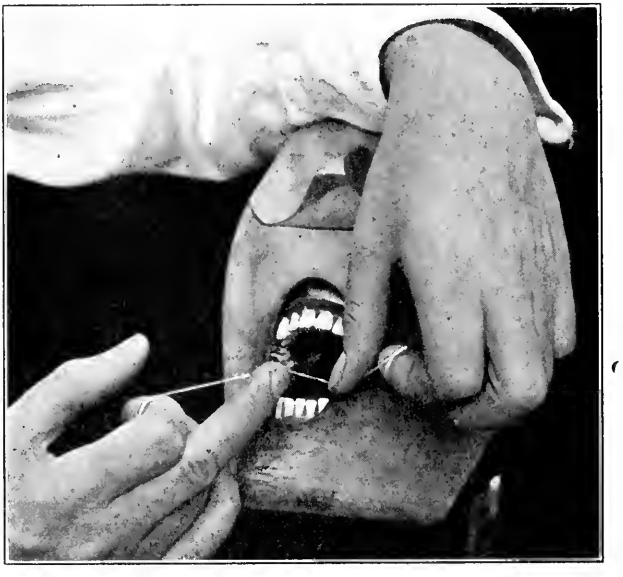


FIG. 199

surface of the tooth and then pressed backward rubbing the mesial surface of the adjoining tooth. Most of the decay takes place in these surfaces and they must be given careful attention. If the ends of the floss are wound around the first fingers as illustrated in Figs. 198 and 199, it can be easily manipulated.

Brush Wheel.—The masticating surfaces are so uneven that a stick cannot be used on them very well, so it will be necessary to use a brush wheel in the engine to reach down in the sulci to polish these surfaces. With the wheel dipped in water and the edge of it touched to wet pumice, the engine should be run at a moderate speed and the edge of the wheel applied down in the sulci of the molars and bicuspids. The Dunn cheek-distender should always be used. It is almost unnec-

essary to state that the sticks, the pumice, the floss and the brush wheel should not be used a second time. Figs. 200 and 201 show the adaptation of this wheel.

Fig. 200

Fig. 201

Children.—In the prophylactic treatment of children it is seldom necessary to use the instruments. As it is the roots of the teeth that are most susceptible to disease in adults, so are the masticating and approximal surfaces most susceptible in children. These surfaces should be carefully polished with the floss and pumice, and the sulci in the masticating surfaces with the brush wheel in the engine. The polishing of all the surfaces of the teeth with the sticks should be done as described for the adult.

To assist in the removal of bacterial plaques and green stains on the surfaces of the teeth, a small napkin should be used to dry the teeth, then with a pledget of cotton Churchill's Compound Tincture of Iodin is applied and allowed to dry. The iodin assists chemically in the removal of plaques and stains. The thoroughness of the polishing operation may be tested by applying iodin to all the surfaces of the teeth after the hygienist considers the operation finished. The mouth is then rinsed with warm water and if the iodin has not adhered to any surface of the teeth, it may be assumed that the plaques have been thoroughly removed.

Attention is called to a preventive treatment of the fissures in the first permanent molars of children that comes within the province of the dental hygienist.

When these fissures are found to be exceptionally deep, likely to retain food débris and thus susceptible to decay, a quick-setting, hydraulic cement should be mixed, and with cotton rolls on each side of the tooth, the fissures should be dried with warm air, and washed with a pledget of cotton soaked with alcohol, again dried and then with an explorer the soft cement worked down into the fissures. As the cement begins to toughen and set, the end of the second finger is dipped in a glass of water and with the ball of the finger the cement is pressed firmly down into the fissures and held there for a moment or two until it has become fairly hard. The surplus can easily be trimmed away and the cement in the fissures will last for some time, acting as a protection to their surfaces. It takes but a short time to renew it when it wears away, and will frequently save these teeth from decay at the susceptible period of from six to twelve years of age.

Instructions for the Home Care of the Mouth.—Brushing.—A remarkable condition of health and beauty of the gums, and a high resistance and increased vitality of the pericementum may be developed by the proper form of brushing. It may be well to first consider the blood supply to the pericementum in relation to the circulation in the gum tissue itself. The blood supply to the pericementum may be described as follows; the small arteries entering the apical space break up into branches, one or more of them enter the pulp canal through the apex of the root and the others pass down through the fibers of the pericementum. During their course through this tissue on their way to the alveolar border and the gums, they both give off and receive branches through the alveolus and connect with the plexus of small bloodvessels and capillaries of the gum tissue. It will thus be apparent that the blood circulation in the gums is very intimately associated with the circulation of the pericementum. It frequently happens that when an alveolar abscess develops at the apex of the root of a tooth, the bloodvessels in the apical space are destroyed yet the pericementum does not suffer from lack of blood, for the branches coming to it from the walls of the alveolus soon enlarge and produce a sufficient supply. It must, therefore, be noted that in order to stimulate the blood supply

of the pericementum it is merely necessary to stimulate the circulation in the gum tissue.

Fibers of the pericementum radiate into the gum tissue and strong bands of fibers which form the dental ligament blend into the periosteum of the alveolar process. Some of these fibers are so close to the surface in the gum tissue that it is not difficult to understand why an unusual response to health may be obtained by surface stimulation.

In the process of masticating coarse foods, a natural massage takes place in the following manner: The coarse foods sliding over the surfaces of the teeth press upward on the upper gums and downward on the lower gums creating a pressure and release on the bloodvessels in the gum tissue which stimulates the circulation.

The teeth being occluded with considerable force are pressed down in their sockets. The pericementum is thus compressed and the blood is squeezed out of the small bloodvessels through the walls of the alveolus. As the jaws open and release the pressure on the teeth, the pressure upon the small bloodvessels is also released and the blood comes rushing in again. This pressure and release is similar in its action to a massage of the tissues on the surface of the body. Such a process always produces a free flow of blood, and prevents congestion or stasis in the capillary circulation.

Keratin.—In the basement layer of the skin, cells are constantly being formed and forced slowly upward toward the surface of the body. During their transit the cells slowly change their shape, becoming long and flat in appearance and finally form the pavement or squamous type of epithelium on the surface of the skin. During this period, from the time of formation to their arrival on the surface of the body, a gradual metamorphosis or change takes place in the protoplasm of the cell. The content of the cell gradually begins to toughen and this process continues just in proportion to the needs of protection against undue friction or exposure. The horny hands of the day laborer, or the corns that form on the feet, are examples of the extreme expression of the activity and change in these cells. The content of the cells when so changed or toughened is known as keratin.

The mucous membrane of the mouth is but a continuation or an infolding of the skin. Its epithelium is of the squamous type similar to that of the skin, but the stratified cells which have the power of forming keratin are found only on those portions of the mucous membrane covering the gum tissue and the roof of the mouth. If the gum tissue is artificially stimulated three or four times a day with the bristles of the tooth-brush, a noticeable change takes place in the texture of the mucous membrane. It soon loses that smooth, glassy or sleazy appearance and under a magnifying glass shows a thickened or toughened surface which seems to act as a protective armor for the underlying tissues and makes the ingress of infection through the gum tissue, or at the gingivæ, extremely difficult. Inference should not be made that there is produced a hornified mucous membrane, except in a

modified sense, but a beneficial change takes place that is much to be desired. A similar texture of membrane may be found in the mouths of carnivorous animals.

The Gums.—In considering the health of these dental tissues the gums found in the average mouth should first be noted. Aside from the unsanitary aspect of the crowns of the teeth, the gums will be found to be of a deep red color, the gingivæ usually showing even a deeper red. The blood is almost stagnant on some of the margins, and the tissues will bleed upon the slightest touch. Waste products are not being properly eliminated, oxidation is imperfect and blood serum, which contains the lime salts for serumal deposits, oozes in the subgingival spaces and forms an ideal medium for bacteria. These are the average gums of adults, who eat food which requires but little mastication and produces but little friction on the gums, and who take scant care of their mouths. But how quickly all of these conditions will change under artificial stimulation. The instant the gums are brushed properly, the blood starts to flow more rapidly and a new life and color make their appearance. After a thorough prophylactic treatment and a lesson in gum brushing it is not unusual to see the tissues lighten in color, possibly two or three shades in twenty-four hours. At the end of a week or ten days they assume a still lighter shade and after periods ranging from three to six months they become a light coral pink, and hold this color as long as they are daily brushed and stimulated.

There is apparently a peculiar pink shade that practically every individual may acquire if the brushing is faithfully followed. In fact this color may be taken for so sure an index, that it is easy to tell at a glance whether the patient has been brushing the teeth and gums four times daily. Virtue, in this case, has its own reward, for the color is always obtained when the brush has been used according to rule. The gums should be of uniform color in all parts of the mouth, the gingivæ showing no difference in shade from that of the body of the gum.

Tissue Stimulation.—If the following rules are honestly observed the same results are assured in every mouth:

1. The form of brushing as described in this chapter.
2. Brushing long enough—not less than two minutes after meals.
3. Brushing four times a day.

Many cases have been baffling because they would not respond to treatment, but when the patient gives a demonstration at the wash bowl, it will show that he makes some omissions or uses an incorrect form of brushing which, when corrected, will bring results in a short time. Sometimes patients will claim to have followed the rules when, upon close investigation, it will be found that they have not done so.

When the gum tissue will not assume this light pink shade in a few months' time, and when the patient is expert with the tooth-brush and

claims to follow the rules faithfully, it may be suspected that in some way the rules are not lived up to or that otherwise a very rare exception has been found.

Evidently this color that the gums assume under the daily brushing is due to the fast flow of blood through the capillaries, the perfect oxidation of the cells and thorough removal of their waste products, as well as a thickening or toughening of the epithelial layer of cells on the surface. The festoons become pink and tough, the surface of the mucous membrane loses its thin, glassy appearance, and when dried looks tough and firm. Also when the edges of the gum are dried they do not weep. Little or no serum oozes now from this tissue and it will be noted that the serumal deposits, found so plentifully under the congested borders of the gums, almost entirely disappear at subsequent treatments. It must not be assumed that the miraculous happens under these unusual health conditions or that merely learning how to brush the gums will eliminate all present and future disease of the mouth. However, one cannot help being enthusiastic when viewing the rapid return to health of the dental tissues under artificial stimulation. The pericementum seems to acquire new life, and apparently feels the stimulation in every fiber and cell. Loose and sore teeth become tight and free from soreness, providing that too much of their supporting tissue has not been lost. Chronic cases of pericementitis disappear and even the pulp itself may be relieved of congestion if it is slight and has not progressed too far. There is no doubt that the osteoblasts, under prophylaxis and this stimulation, do at times replace small areas of lost alveolar process. Where roots have been exposed on the labial or approximal surfaces, especially those of the incisors and cuspids, it is not uncommon to see gum tissue creep back over the exposed root to a considerable degree and on approximal surfaces there has been a filling in of the bony tissue to support the gum which is undoubtedly a new deposit of process. When it is considered that the osteoblasts are present in the peridental membrane throughout life and slowly add to the alveolar wall of the socket, it is not unreasonable to expect them to lend their aid when stimulated and the irritating cause is removed.

It seems probable that it is not only possible to sterilize tissue by this perfect circulation, artificially induced, but also that small serumal deposits may be dissolved and disposed of by the blood or possibly by the action of the cells in these tissues. This statement does not mean that when the dentist treats surgically a case of pyorrhea alveolaris, merely teaching the patient how to brush his gums will cause the dissolution of the deposits and kill the infection. It is exceedingly important that gum brushing should be taught and the patient trained by repeated lessons until he acquires this art, for it really is an art. With the additional aid of the gum brushing the pus will soon cease, the pockets will contract and close, soreness will be relieved and any small granular deposits that may be left will gradually

disappear as the tissue hugs up tightly to the root. The tissues thus artificially stimulated seem to possess five properties. The first may be termed analgesic, or the relief from pain. This analgesic action is the result of reducing the tension and pressure on nerve terminals from enlarged and engorged bloodvessels. There is also a bactericidal action or the destruction of the infection by increasing the flow of blood to the parts. This sterilizing process induced in the cells of the body by a perfect circulation is well known, and it is a subject of considerable discussion as to whether the action is produced by phagocytosis or opsonins. Under artificial stimulation the cells have also a solvent power. That is, they are able to disintegrate irritating or foreign substances. It is a well-known fact that a ligature of catgut in the body is dissolved and disappears. Landois has shown that the blood serum of every animal has the power of dissolving the blood corpuscles from a different species. The origin of the solvent which disintegrates granules of serumal deposits can only be conjectured, but it is a fact that they do disappear as a result of perfect circulation.

The eliminative property is greatly facilitated and permits the lymphatics to readily absorb and dispose of waste products and irritating substances. There is also the nutritive property which is self evident, and is due chiefly to a perfect oxidizing process. There is still much to learn concerning these artificial stimulants. If the existence of human beings were more like that of animals, this condition would be induced each time that the meal of coarse food was chewed. Since the artificial rather than the animal life is preferred, and coarse food is not attractive, why should not this condition of health be produced artificially?

Tooth-brushes.—Opinions vary greatly concerning the size and shape of the tooth-brush. One educator of the middle West states in a letter that he did not recommend a hair-brush, a nail-brush or a shoe-brush for brushing the teeth, but a *tooth*-brush. His position might have received serious consideration if it were only the crowns of the teeth that were involved, but as the brushing of the gums and the roof of the mouth is of equal importance with brushing the teeth, a brush that will adapt itself to all these surfaces is the one to use. In fact this process may be better termed *mouth-brushing*.

If cross-wise brushing is indulged in or a slow twisting massage or wiping motion is employed, the form and size of the brush may be varied. Personally, the writer has not been able to secure as satisfactory results with either of these forms of brushing. The cross-wise brushing seems to irritate the festoons, at times create absorption, and lacks the cleansing action upon the outside surfaces. The wiping motion with the sides and ends of the bristles is more cleansing and the gums take more kindly to this form of brushing, but this motion is necessarily slow and lacks the stimulating effect produced by a fast stroke. When it is considered that nature intended that the pressure should be chiefly upward on the upper gums and downward on the

lower gums, such as is induced by food sliding over the surfaces of the teeth in mastication, it can be seen that this process can be better simulated by a circular stroke than by any other. The gums appear to thrive under the circular stroke, a stimulus is imparted to the circulation and a thorough cleansing effect is produced along the curved lines of the festoons and upon a third of the approximal surfaces. A slow, deliberate stroke is not as stimulating as a fast, light stroke. The best way to bring blood to the surface of a tissue in a short space of time is to use a light, rapid massage.

The results will justify the means, so a circular stroke for the buccal and labial surfaces is advised. In order to secure the proper adaptation of a brush to the surfaces of the gums and the teeth, the shape of the bristle ends of the brush is important. Many of the popular brushes on the market are nearly concave in shape, having a long toe and heel with the shorter bristles near the center. Such a brush, placed squarely across the front teeth, seems to fit when at rest, but if slowly moved

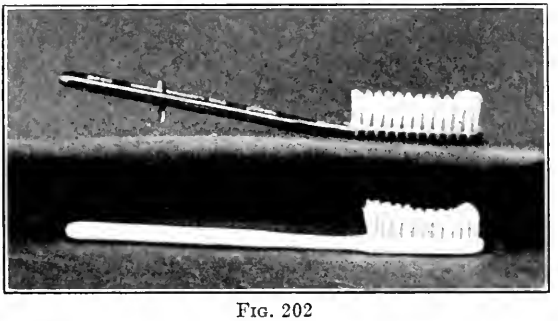


FIG. 202

about the mouth, it will be found to ride in many places on the toe and heel alone or, if pressure is used, these long bristles ride sidewise or any other way. Although the cranium is convex in shape, it has never been deemed expedient to use a concave hair-brush. In fact, a concave brush would not be as effective as a straight one, although it might seem to fit better when at rest. A straight-cut tooth-brush with a slight tuft on the end is best adapted to most of the surfaces in most mouths. The bristles should be of sufficient length to be flexible yet springy and stiff enough not to lose their life or spring after the first two or three days' use. This necessitates using a brush with bristles a trifle hard, for such a brush becomes softened after a few days' use. Fig. 202 illustrates the two shapes of brushes just referred to. When instructing a new patient in the art of brushing, a soft brush should be recommended to start with, or the patient should be warned not to be too strenuous with the stiff brush until the gums have had a chance to become tough and the mucous membrane thickened, otherwise slight abrasions of the mucous membrane will be produced, and a sore

and tender surface will result if the gums are brushed at first with too much pressure and vigor and with a stiff brush. It is a well known fact that in the use of a fairly large brush with three or four rows of straight-cut bristles, set well apart, the pressure on any one point is considerably reduced in proportion to that produced by a shorter and narrower brush. For this reason the best results from mouth brushing in adults may be obtained when it is possible to use a large brush.

Instructions for Brushing.—The process of the brushing of the mouth may be divided into three parts:

First, the outside or buccal and labial surfaces of the teeth and gums.

Second, the inside or palatal and lingual surfaces.

Third, the occlusal or masticating surfaces of the teeth.

Fig. 203

The Buccal and Labial Surfaces.—With the brush held in the hand, as in Fig. 203, and with the teeth nearly closed, the brush is placed inside the cheek on the left side, so that the ends of the bristles are lightly in contact with the gums over the upper molars. Now, with a fast, circular motion the brush is swept backward and downward, reaching as far down on the lower gums as the brush can travel in this position, then forward and upward as high on the gums of the upper teeth as possible (Fig. 204).

The brush should travel in a perfect circle, not in an oblong tract, and in as large a circle as the vestibule of the cheek will permit. Very little pressure should be used, for the stimulating as well as the cleansing

process is accomplished by the rapidity of the stroke and the direction traveled by the ends of the bristles. Continuing this fast, circular

Fig. 204

motion the brush should be made to travel very slowly forward until the heel (the bristles nearest the hand are called the heel) engages the

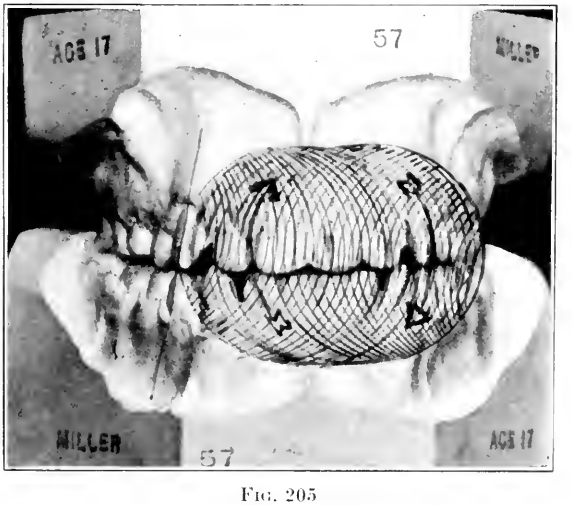


Fig. 205

right cuspids. Pausing on the incisors to stimulate thoroughly the gums on both jaws, start back again slowly to the region of the molars (Fig. 205).

It will be understood that the brush is constantly in rapid motion, travelling in a large circle with the ends of the bristles lightly touching the gums and teeth.

FIG. 206

Fig. 206 illustrates the position of holding the brush for the right side. On this side some persons find it easier to maintain a circular

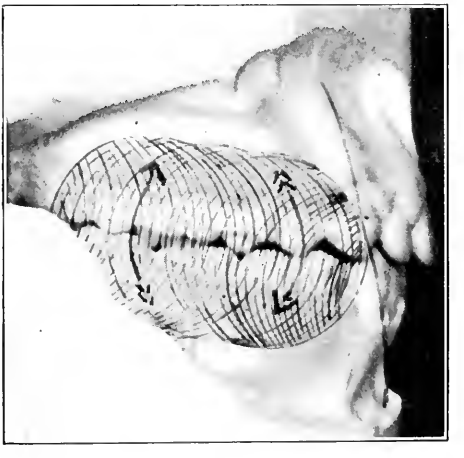


FIG. 207

motion by reversing the stroke, or brushing from the lower gums backward and upward. It makes no difference in which direction the brush

travels as long as the circular stroke is adhered to. Assuming that one is using the right hand for brushing, it will not be possible to brush farther forward than the right cuspid teeth (Fig. 207). Directions for brushing the left side are applicable to the right.

Lingual Surfaces.—1. *Upper.* The brush should be held as shown in Fig. 208. The roof of the mouth as well as the lingual surfaces of the upper teeth are brushed with an in-and-out stroke, as in Fig. 209.

The festoons on the palatal and lingual surfaces cannot be properly brushed with the circular stroke. It may be noted that they assume a much straighter line than on the buccal and labial surfaces. Therefore the bristles travelling in and out with this straight line reach all surfaces and are stimulating and non-irritating in their action.

FIG. 208

The ends of the bristles should be placed against the gums of the right molar teeth, and the brush drawn straight forward until the heel wipes the lingual surfaces of the right incisors and cuspids and protrudes from the mouth for a short distance. The upper lip should be drawn downward to prevent the moisture from being thrown outward by the snap of the bristles passing over the edges of the incisors. The brush is now pushed straight back again on the gums and this in-and-out stroke is rapidly made and confined on this surface for a few seconds. This fast in-and-out stroke of the brush is kept up and carried across the roof of the mouth until all of the hard palate is covered and the gums on the left side of the mouth are reached. Here the in-and-out stroke is applied rapidly for a few seconds, as far back as the distal surfaces of

the third molars. The same stroke should be used on the return, the palate should be crossed to the right side again, and again back to the left side. Special care should be used to reach the gums around the last molars, as there is a tendency not to brush back far enough.

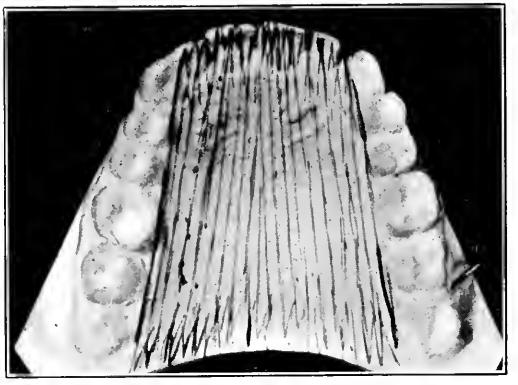


FIG. 209

2. *Lower Lingual Surfaces.*—The lingual surfaces of the lower teeth are the most difficult to brush and it requires quite a little practice before

FIG. 210

the gums, especially on the right side, can be deftly reached. Nineteen out of twenty mouths will disclose a congested gingival border on the lingual surfaces of the right lower molars, and in order that the wrist

may bend freely so that the toe of the brush may reach this surface, it is suggested that the brush be held in the hand as in Fig. 210.

These gum surfaces are brushed almost entirely with the toe or tuft of the brush, the motion being a fast in-and-out stroke, similar to that

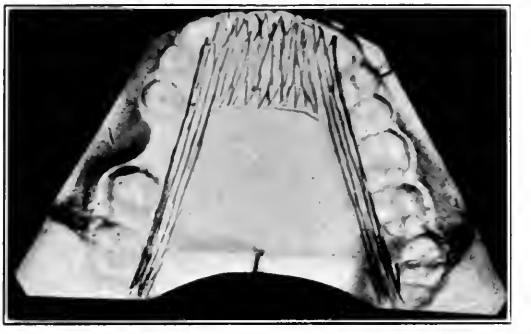


FIG. 211

used on the hard palate, as in Fig. 211. Starting on the right side with the bristles of the tuft resting on the gum next to the last molar, the brush is drawn forward. In this case the bristles at the heel do not sweep the lower incisors as the handle of the brush is tipped slightly upward.

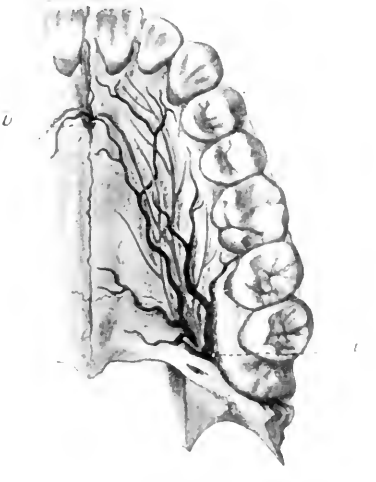


FIG. 212

The brush is now forced backward in the same line, leaning slightly toward the tongue, and the in-and-out stroke is applied rapidly to this surface. Maintaining always this fast stroke, and slowly coming forward, the handle of the brush is now raised to a sharp angle and the gums below the incisors are brushed with an up-and-down stroke,

going back and forth across them several times. Continuing the in-and-out stroke the tuft is adapted to the gums of the left side and they are brushed in a manner similar to that described for the right side, again slowly returning to the right and repeating once more to the left side. A slight gagging sensation will sometimes be felt in trying to reach as far back as the brush should actually go, but with persistent practice this can be greatly overcome in a short time.

Masticating Surfaces.—Lastly the masticating surfaces should be brushed in order to remove any food débris in the fissures or sulci of the molars and bicuspids. The tuft of the brush should also be carried to the distal surfaces of the last molars on both the upper and lower jaws and with a wiping or twisting motion these surfaces should be cleansed.

The foregoing description of brushing gives but a stereotyped form. The mouth should be gone over three or four times until the gums begin to tingle and a slight sense of numbness is felt.

In the roof of the mouth are the posterior and anterior palatine arteries which help to supply the gum tissue, hence the importance of brushing the hard palate (Fig. 212).

It should be noted that the brush is used with a full-arm motion and that a fast but light stroke is essential to secure the desired results.

Number of Daily Brushings.—Not so very many years ago more than one bathtub in a private house was considered a luxury. Today it is realized that frequent bathing is a necessity.

Some dentists advise their patients to brush their teeth before retiring; some, night and morning; and the patient who followed this last rule, thought himself virtuous indeed. The matter of brushing the teeth is purely educational and resolves itself into a habit. Time can always be found for any habit—it is merely a question of what habits are acquired.

After each meal a certain amount of food is retained on the surfaces of the teeth. In less than an hours' time this food begins to decompose. If the teeth are brushed at night and in the morning before breakfast, remnants of the breakfast remain on the teeth until bedtime, joined through the day by those of lunch and dinner. There may be some arguments in favor of not disturbing the decomposing food in the mouth all day, but such arguments are usually based on the statement that people do live with unbrushed teeth, so why handicap them with an extra daily duty when they have so little time to spare. Those who advance these arguments usually have a breath far from pleasing. It cannot be shown scientifically that a mouth containing decomposing food is as healthy and wholesome as one that is free from it.

The teeth should be thoroughly cleaned after each meal with brush and dentifrice, and given a vigorous brushing with clear water the first thing in the morning. This means four brushings a day. Of course it is not always possible to follow this rule to the letter, but where one has access to a bowl and one's tooth-brush, the teeth should be

cleaned. All children should be taught this habit, as there can be no greater insurance for health and freedom from infectious diseases than a mouth free from decomposing food.

Dentifrices.—The most important ingredient in a dentifrice is soap. Next, a mild abrasive, such as a fine grade of precipitated chalk. The rest of the formula is of but little value and is used chiefly to disguise the soap and impart a pleasant taste. The removal of grease is a chemical action and soap is essential for thoroughly cleaning the teeth. If fat is rubbed on the hands or on a slab of glass it will be difficult to remove it with clear water and a brush. Although with considerable effort it may be done, soap will remove it much more quickly. A fine grade of powdered Castile soap is the best, but it is seldom found in the preparations on the market, as it does not give sufficient lather to suit either manufacturer or purchaser. The most harmful constituent in a dentifrice is a gritty, coarse grade of chalk. The teeth should be cleaned, not scoured, and the daily use of a gritty dentifrice will eventually cause abrasion of the thin enamel surfaces at the necks of the teeth. In fact some preparations contain pumice and in one foreign production, powdered oyster shells were found. The grit may be readily detected by placing some of the paste or powder between the teeth and biting on it. Finer tests may be made by putting it between two glass surfaces, rubbing them together and examining them with a magnifying glass.

A mild abrasive is helpful in the removal of the slippery film of mucin and viscid accretions on the surfaces of the teeth. Its daily use is harmless providing the grit is fairly soluble and not coarse. When one computes the number of occlusions that take place daily between the masticating surfaces of the teeth during the three meals and notes what little wear of the enamel cusps is exhibited at thirty-five or forty years of age, it may be concluded that the use of a fine grade of precipitated chalk as a base for a dentifrice is not a serious menace to the enamel tissue. There is but little choice between powder and paste, as regards efficiency. Powder has to be worked into a past-like condition in the mouth with the brush, while paste quickly spreads itself over the teeth for immediate action. The majority of people find the paste much more pleasant to use. The difference in the formulæ of the two preparations consists in leaving out the saccharin in the powder and mixing the powders and oils with glycerin to form paste.

A simple, cheap and effective power may be made by placing the following ingredients, all of which may be bought at any drug-store, in a quart Mason jar:

Finest grade English precipitated chalk	½ pound
Powdered Castile soap	1¾ ounces
Light carbonate of magnesia	⅓ ounce
Oil of clove	46 drops
Oil of wintergreen	35 "
Oil of sassafras	35 "
Oil of peppermint	18 "
Saccharin—finely powdered	4 grains.

The glass top should be securely fastened and the contents shaken vigorously. The mixing process takes some time as it takes at least twenty-four hours for the oils to permeate the powders, but the jar may be picked up at varying intervals and its contents thoroughly shaken. A larger bottle with the same quantity of powder will permit of a more thorough mixing in a shorter time.

The brush should be very wet when the powder is placed upon it and care should be taken not to inhale when introducing the brush into the mouth.

A properly prepared tooth paste is a much more pleasant toilet article to use and, as there are some on the market quite effective and harmless, one of these may be recommended to patients.

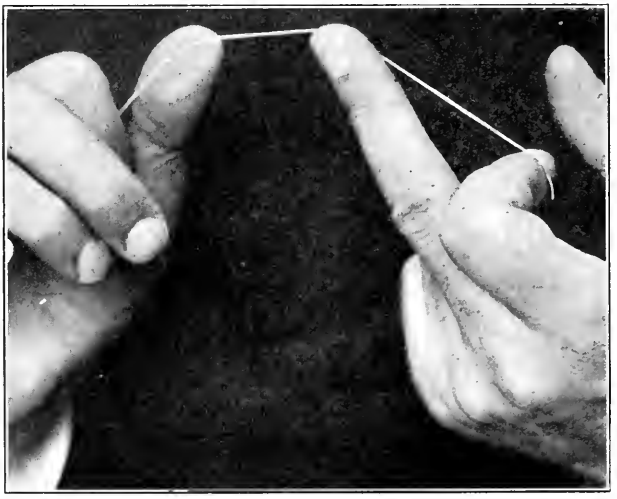


FIG. 213

Each tooth has five surfaces. Three of these can be cleaned with the brush, but the two approximal surfaces, the most susceptible of all, cannot be reached with it. In other words three-fifths of the surfaces of the teeth can be cleaned with the tooth-brush but not the remaining two-fifths which most need it. It should then be apparent that if all the food is to be cleaned off all the surface of all the teeth, additional means of so doing must be employed. Up to the present time nothing is known that will accomplish this more efficiently and harmlessly than the floss silk and a mouth wash of lime water.

Floss Silk.—If the floss silk is skilfully and frequently used, the approximal surfaces may be kept quite free from dental caries. To induce patients to use the floss silk with regularity is a task, but by being persistent in requesting and logical in the reason for its use, they may be made gradually to acquire the floss habit. To insure the proper use of the floss the fillings in the approximal surfaces should be smooth

and polished, with just sufficient pressure at the contact points to allow the floss to snap through without too much effort in forcing it. The patient should be instructed not to allow the floss to snap through on

FIG. 214

the gum tissue hard enough to wound it. There is but little danger of this after practice, especially after the gums have become hard and

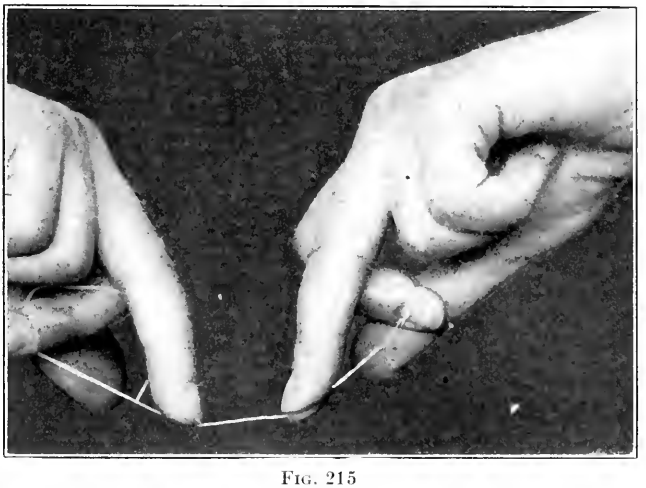


FIG. 215

tough from brushing. A reasonably small-sized waxed floss is the best to use. For adults the piece should be fourteen or fifteen inches in length. The end of the floss is taken between the thumb and first

finger of the left hand and two wraps made around the end of the first finger, and this act repeated with the other end of the floss on the right forefinger. The floss is now held securely and will permit the

FIG. 216

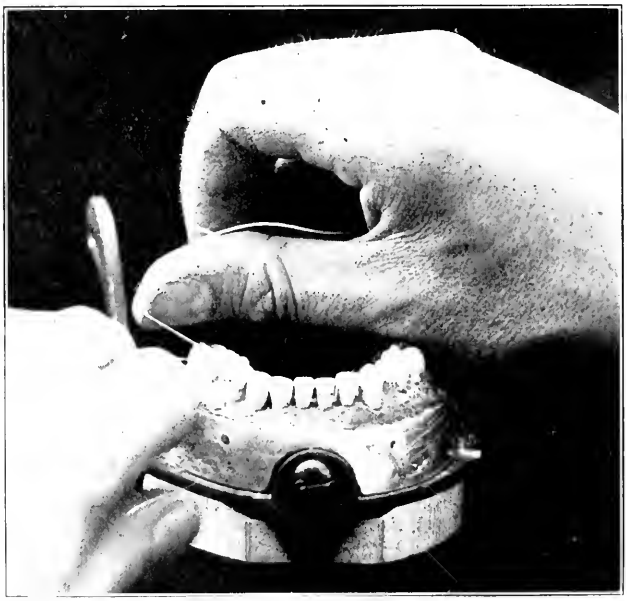


FIG. 217

ends of the two thumbs or the two second fingers or a combination of a thumb of one hand and a second finger of the other, to guide the silk into its position in the mouth and force it between the teeth. Fig. 213 shows adaptation of floss for right upper teeth. Fig. 214 shows adaptation for left upper teeth. Fig. 215 shows adaptation for all the lower teeth. After the floss has passed through the contact points it should be rubbed back and forth against both approximal surfaces to polish them mechanically. In withdrawing the floss, if the end held opposite the lingual surface is brought over on the buccal surface and the silk is pulled through the contact points in the form of a loop, it will be more effective in polishing or cleaning these surfaces than if merely snapped out (Figs. 216 and 217). The floss will not, however, thoroughly remove all the food between the teeth, therefore we must have recourse to a mouth wash.

Lime-water.—Practically all the mouth washes on the market are formulated to accomplish two results: First, a neutralizing action, either acid or alkaline, and second, a germicidal action. It will readily be understood that the latter result cannot be obtained in the mouth, while the former is immaterial. In order to secure immunity to decay, the bacteria must be robbed of any pabulum upon which to feed and any plaques or glue-like accumulations on the surfaces of the teeth must be dissolved.

Acid mouth washes have been advocated because it has been found that the lactic acid forming bacteria are retarded in their growth and activity in an acid medium. Alkaline washes have been prescribed because of the belief that they will neutralize any lactic acid formed that will induce caries. Both of these theories are based on partial facts only, for it has been absolutely proved that the chemical action of an acid or an alkali used as a mouth wash for neutralizing purposes will not inhibit dental caries to any great degree. All of these washes are supposed to contain germicides that will immediately destroy the microörganisms of the mouth. This is of course untrue, especially when the short time they are retained in the mouth for this purpose is considered. The peroxide of hydrogen is religiously used by many, in the belief that the oxygen liberated is a germicide of sufficient power to destroy all the bacteria. The mechanical action of the peroxide in its boiling process, while it does liberate the oxygen, is more effective in dislodging particles of food débris around the necks of the teeth than in its germicidal action on the organisms in the mouth. In the study of dental caries it must be concluded from the present knowledge of the subject that in the main Professor Miller's theory still holds good, namely, that the exciting cause is due to the production of lactic acid by the action of microörganisms on carbohydrates, and that decay takes place most readily on those surfaces least exposed to friction during mastication, such as the fissures or pits, approximal surfaces, and the necks of the teeth. Dr. J. Leon Williams was the first to point out the fact that a thin gelatinous plaque was first formed on the

surface of the enamel and under and in this thin film the bacteria obtained a secure position that made their dislodgement difficult. Their action in the production of acid was intensified when thus protected. Other scientific investigators have corroborated Williams' observations. Laying aside any theories regarding susceptibility and immunity, it must be admitted that the battle just now should be the thorough removal of all food débris and the removal of these plaques and glue-like accretions.

The mucin, which is a product of the salivary and mucous glands, plays an important part in the formation of these plaques, and it is precipitated from the secretions in the mouth by the presence of an acid. This precipitate forms on the surfaces of the teeth and becomes the factor in incasing the bacteria with food débris and in forming the so-called plaques. Mucin thus precipitated is soluble in or may be dissolved by an alkali. It has been found that the presence of fruit acids in the mouth stimulates the salivary secretions in amount and alkalinity. It is claimed by some investigators that the increased alkalinity of the saliva has a solvent action on the precipitated mucin and a neutralizing action on lactic acid and thus becomes a natural preventive of dental caries. Other investigators have as yet been unable to find that the alkalinity so produced is of sufficient strength to have this solvent action. Again, it is claimed that the acids of fruits have a curdling effect on the mucin, forming it into flakes which are easily removed from the tooth surfaces.

There is a serious question concerning the habitual use of these acids for this purpose. Prinz states, as his opinion, that the correctness of the use of acid mouth washes is not substantiated by clinical experience, that the pharmacological principle evolved in the selection of such solutions is erroneously applied, that constant forcible stimulation of the salivary glands by acids is followed by an impairment of glandular function and that the acidity of the solution kills the important salivary ferments. A reasonable amount of fruit is healthful and desirable, but dentifrices and mouth washes containing fruit acids, must be used with considerable judgment.

The most cleansing and the least harmful of all fruits is the apple. This with its dense texture acts as a mechanical cleanser, and the malic acid is comparatively harmless. Where it is impossible to have access to a tooth-brush the eating of an apple will be found an excellent substitute.

If it can be scientifically shown that dentifrices and mouth washes containing fruit acids in certain proportions are harmless to the teeth and the tissues of the mouth and are superior to any of the present-day preparations as prophylactic agents for dental caries, it would prove to be a valuable contribution to dental prophylaxis.

As it will take a number of years to demonstrate this as a fact it will be necessary for the present to adhere to those agents that have proved themselves to be harmless and efficient in the past.

There is a harmless solvent for the mucin on the surfaces of the teeth that is quite positive in its action. This solvent is lime-water, and is made from the coarse calcium oxid or unslaked lime. Its preparation is simple and cheap, and when its efficiency for the use and purpose intended is considered, it will rank as an important agent for the prevention of dental caries.

Some coarse lime, such as is used in making rough plaster, may be secured from a paint store or from a mason. The refined product found in the drug-stores apparently does not have the same effect. The refining process robs it of some of its beneficial properties. It is cream white in color. The lumps should be broken up into coarse powder and a half-cupful put into a quart bottle. The bottle should be nearly filled with cold water, room enough being left to permit of

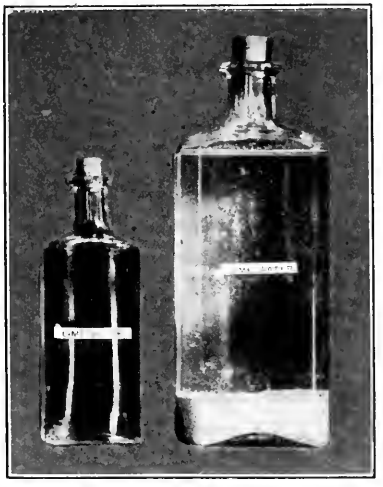


FIG. 218

thorough shaking, shaken vigorously and set aside for three or four hours to allow the lime to settle. Then as much of the clear water as possible should be poured off, for this contains the washings of the lime. It will be found impossible to pour off all the water without losing some of the lime, but by pouring slowly nearly two-thirds may be drawn off. The bottle can then be filled with cold water and shaken thoroughly, when, after it has settled again, it will be ready for use. A bottle of convenient size should be procured; one holding ten or twelve ounces, and filled with the clear water from the large bottle. This smaller bottle will be more convenient to use at the bowl. The large bottle can be again filled with cold water, shaken thoroughly and set aside to be used as needed (Fig. 218). This operation may be repeated over and over again, for the original half-cupful of lime will make five or six quarts of lime-water. If the first

use of the wash proves that it is a little strong, it can be diluted in the small bottle. With new patients and those having tender gums it may have to be diluted, but as soon as possible it should be used undiluted. When taken into the mouth it should be forced back and forth vigorously between the teeth with the tongue and cheeks and the rinsing continued until it breaks into a foam. Not that there is any particularly beneficent action to the foaming, but if it is worked through the teeth long enough to make the foam it will have been in contact with the surfaces of the teeth long enough to have a disorganizing action on the mucin and plaques. Afterward the mouth should be thoroughly rinsed with warm water to take away the taste of the lime-water. It is the unpleasant taste of the lime that makes it difficult to induce the patients to use it at the start, but after a short time the cleansing effect is so pleasing that they soon forget about the taste. It may be flavored with saccharin or any flavoring material, but this will hardly be found necessary. The lime-water should be used after the brushing and flossing, after each meal.

Diet.—The greater part of this chapter has been devoted to a detailed description of the operative procedure for dental hygienists to follow and the instructions for home care of the mouth which she is to teach.

It must not be assumed that the foregoing is, therefore, the most important part of dental prophylaxis. On the contrary, the hygienist will find by experience that, despite the most conscientious effort on her part, there will be mouths in which dental caries is never under control. In these cases it will be found that the diet is such as to counteract the most painstaking care on the part of the patient and hygienist. It may be truthfully stated that, aside from the influence of heredity, the controlling factors in mouth health are *diet* and *extreme cleanliness*.

The most important study of the dental hygienist should be that of foods, and the influence which she can have on mothers and children in this respect will be her most important educative service. The subject of foods must be studied in great detail, and it is possible in this chapter to mention only the most salient points regarding the relation of the dietary to the teeth.

During infancy and childhood, the important single substance for the growth of bones and teeth is calcium phosphate, and the amount of calcium available for tooth formation regulates whether the enamel be hard and dense or relatively soft and porous. The influence of diet and its relation to the teeth must therefore begin with pregnancy. Before birth and for some time thereafter, if the infant is nursed at the breast, the high calcium requirement of infancy is supplied by the mother. Her calcium requirements are consequently increased, and unless extra lime is present in her diet, her teeth and skeleton may suffer. Milk, which is a perfect food, contains all the necessities for infant growth, but when milk ceases to be the sole article of food, the new diet is most important. Especial emphasis should be placed

on foods that are high in calcium content as soon as the temporary teeth have erupted. Some of the most important of these foods are milk, buttermilk, cheese, celery, spinach, turnips, radishes, string beans, parsnips, carrots, kidney beans, cabbage, cauliflower, onions, etc. It is also present in the various whole grains and it is well to note that the more highly refined the grain is, the less calcium it contains.

Alfred W. McCann, in his book *This Famishing World*, says: "The unrefined grain of wheat as it comes from the field contains in organic form the twelve mineral substances needed for the health, growth and life of the body. White bread becomes white because from the ground grain of wheat three-fourths of the mineral salts and colloids, including the salts of calcium, phosphorus, iron, potassium, chlorine, fluorine, sulphur, magnesium, manganese, etc., are removed. These mineral substances are contained in the brown outer skin, the cells underneath this skin and the germ of the wheat berry. They are sifted and bolted out of the ground meal, leaving behind the white, starchy cells and the refined gluten of the interior part of the berry."

All of our cereal foods, such as rice, corn and oats, are demineralized during a refining process which should never be permitted. The hygienist has a most important duty in educating people in the use of natural refined grains.

Inorganic calcium is present in drinking water and in lime-water and can be absorbed from them in small quantities. It is interesting to note, however, that a quart of milk contains more absorbable calcium than a quart of clear saturated lime-water, and that milk used freely as food in youth is the most practical means of insuring an abundance of calcium in the dietary. The diet depends so much upon the digestive capacity of the child, that in some cases calcium is not utilized correctly because of some digestive disturbance. The most common is that caused by the ingestion of too much sugar which frequently causes digestive disturbances unfavorable to the absorption of the necessary amounts of calcium.

McCann says: "Sugar and calcium possess a remarkable affinity for each other. When refined sugar or glucose, both of which are mineral-free and, therefore, like distilled water, mineral-hungry, are consumed in generous quantities they attack the soluble calcium of the tissues. The tissues retaliate in turn by sapping the calcium of the blood. The blood, which demands a minimum calcium content, with never relaxing energy, steals calcium from the teeth and bones. The experiments of Voit and others prove this. Children will suffer and prospective mothers decline as long as they consume an excess of refined or denatured, mineral-free sugar, glucose and starch in their diet or as long as food industries continue to remove the soluble mineral elements from the chief sources of their food supply."

In fact when the diet of the average American child is considered, it is not so astonishing to find that dental caries is a universal malady. Originating as it does from carbohydrate fermentation upon

the teeth, no other result could be expected among the children of a nation averaging nearly one hundred pounds of sugar per capita per year. The writer personally believes that in childhood, a well balanced diet, with special emphasis upon the calcium content foods, and the elimination of free sugar would result in practical immunity from dental caries, even in the absence of a rigid system of mouth cleanliness. The causes of susceptibility and immunity are still under investigation, but it is reasonable to believe that susceptibility is mainly in proportion to the consumption of free sugar, and that immunity is acquired, in a great measure, by the absence of free sugar in the dietary. When it is considered that dental caries can only be produced from starch and sugar, and that the starch must be reduced to dextrose before it can be converted into lactic acid, it is quite truthful to make the statement that all dental decay is produced by sugar. Clinical experience and general observation seem to show, however, that the high consumption of starchy food, if unaccompanied by free sugar does not result in dental decay. In fact the evidence is all against the sugar. Among the peasant classes of Italy, Greece, the Balkan States, Germany, and others where the diet consists mainly of coarse foods, vegetables and fruits, but where free sugar is a luxury and cannot be indulged in, decayed teeth are the exception and not the rule. This is also true of the Esquimos, the African Negroes, the American Indians, the Maoris of New Zealand, and many of the South Sea Islanders.

Free sugar consumption in Italy averages but thirteen pounds per capita per year—less than a teaspoonful a day. The American mother would be inclined to question an average of about one hundred pounds per capita per year in this country, but few realize the enormous amount used weekly in the average home for cooking alone, not to mention the quantity utilized in preserving fruits.

The medical profession is, to a great extent, responsible for this situation, for the family physician has taught mothers to believe that free sugar is an essential food for growing children. Under the existing conditions what chance has an American child to have sound teeth? If he is a modified milk baby, sugar is added to the milk, in the proportion of one ounce in twenty, at only a few weeks after birth, and all too frequently cane sugar takes the place of milk sugar. The taste and craving for sweetened foods is developed at once and is steadily encouraged as he progresses to cereals with sugar, puddings, jellies, sweetened crackers, etc. To the *normal* sugar supply found in milk, vegetables and fruits, and in the conversion of starchy foods, is added an ever increasing amount of free sugar at meal time, augmented between meals by soda water, ice-cream and candy. The sugar consumption is so excessive that the liver is overloaded with glycogen and it is very possible that herein lies the secret of the child's susceptibility; not only in the fermentation of the sugar on the tooth, but also in the action of osmotic forces through the enamel with the blood and body

juices which are surcharged with glucose and the absorbed products of fermented surplus glucose from the intestines. There can be but one result; the deciduous teeth are attacked by dental caries, and at the beginning of his school life the child presents a wrecked mouth and it is only a matter of time before the permanent teeth are similarly affected.

And so the medical profession, by advocating free sugar as part of the diet, is constantly creating a disease known as dental caries which demands a specialty known as dentistry. Dentistry, in turn, has filled, crowned and capped these decayed teeth in innocence and ignorance of the bacterial colonies which exist on the ends of the roots of pulpless teeth, causing secondary infections of the heart, kidneys, joints and other organs and tissues of the body, thus returning the compliment to the medical profession by creating thousands of cases of systemic infection to be given over to its care and treatment—with the public as the victim. Neither the medical nor the dental profession has realized that this vicious circle existed, but no great reduction can be made in dental caries and resultant systemic infections until this circle is broken.

The dental hygienist must be the one to break this circle, by teaching American mothers who have for generations been educated to look upon free sugar as a food, that free sugar is the chief cause of dental decay and that dental decay is the chief cause of many of the serious illnesses of childhood and adult life. Until the time comes when these truths are generally recognized, the effort must be made to counteract the evil effects of a faulty diet by a rigid system of mouth cleanliness to lessen the carbohydrate fermentation. The sugar consumption has increased amazingly during the past forty years, and if dentistry, as a science, had not advanced so rapidly during the same period, ruined mouths would be even more prevalent.

The soft pappy foods, which very often constitute the bulk of the diet of younger children, require so little mastication as to seriously hamper the normal development of the jaws, face, and even the brain case itself. It may also be well to mention the deleterious effect on the enamel of the teeth, of skin diseases, especially if contracted during early childhood. It is very important to instruct mothers that the enamel is formed from cells similar to those of the skin and that any eruption or rash of the skin is likely to produce a deleterious effect upon the formation of the enamel, if it occurs during the formative period.

Every precaution should be taken to prevent a child from contracting measles, chickenpox, scarlet fever, etc., especially from birth to about fourteen years of age during which period the enamel of fifty-two teeth is formed.

It is quite common to see teeth with an enamel surface that is pitted or grooved, and in many cases as much as half of the crown of a tooth will be minus any enamel due to some skin disturbance during its formation. Enamel somewhat similar in appearance can also be produced by any severe nutritional disturbance. It is practically impos-

sible to prevent the decay of this defective enamel, and any rash or eruption should be avoided for this reason.

General Comments.—One prophylactic treatment does not constitute prophylaxis. It is only by a systematic, continuous course of treatment and home care of the mouth that ideal health conditions can be secured.

Preventive dentistry can be had quite cheaply and is within the reach, financially, of nearly everybody. Good operative dentistry is expensive and always will be, as is surgery or the services of any educated and skilful specialist.

Education and prevention is the only hope of solving the dental problems for the masses and as time goes on this service will be found as necessary a form of insurance for health as life insurance is for the protection of those left after one dies.

When the public really becomes educated to the fact that for the expenditure of a very moderate sum of money and a little energy on its part, the teeth may be retained throughout life quite free from pain and disease, there will be a great demand for this form of service. Every mouth would be greatly benefited if prophylactic treatments could be administered every two months. Many mouths require monthly treatments, especially those of children and adults who are susceptible to caries.

In the search for some easy solution of the problem of dental decay many ideas are advanced for its ultimate control, and it is expected that a simple method of doing away with this great disease-producing disorder will be found. There may come a time when a lozenge will produce immunity but that time is not in sight as yet. As long as people live artificially, as most people do, eating the various concoctions called "food" that they feel free to eat at the present time, the one hope of escape from the ill-effects of dental decay and its attending serious effects on the body is through the present knowledge of extreme cleanliness, or mouth hygiene. Until something can be presented more definitely simple that will show equally beneficial results, it will be necessary to adhere to the form of prophylaxis herein advocated.

APPENDIX.

THE BROAD FIELD OF SERVICE OF THE DENTAL HYGIENIST.

The educational and preventive service of the dental hygienist has been covered in detail under Dental Prophylaxis, and it remains to state the broad field to which such service may be applied.

It has long been realized that the dental profession was unable to cope with the universal need for mouth hygiene, the number of dentists available at any one time being always insufficient to supply even the need for good operative dentistry. With dental diseases and resultant systemic infections almost universal maladies, trained workers for maintaining mouth health can no longer be denied to a public sorely in need of such service. The dental hygienist was created from the realization that mouth hygiene was a necessity, that the average dental practitioner could not give the necessary time to it, and that the tooth brush alone would never produce it.

Fortunately it does not require a graduate dentist to perform a prophylactic treatment of the teeth, or to teach mouth brushing, food habits, and general hygiene. The present need of the dental profession, in solving the public health problem of mouth hygiene, is an immense corps of women workers, educated and trained as dental hygienists, and therefore competent to enter dental offices, infirmaries, public clinics, sanatoriums, factories and other private corporations, to care for the mouths of the millions of adults who need this educational service so urgently. The need in every state is so great that every state must provide its own training schools, and if the dental profession will not meet the situation, the state health or educational authorities must do it. This is the only sane and logical method by which any help can be provided for the adult population, with the almost hopeless mouth conditions which now prevail. The damage has already been done and there are not enough dentists to restore the lost tooth structure in one-fifth of these mouths. There is, however, a service that the dental hygienist can give in correcting the uncleanliness and in educating for the prevention of further disease.

THE DENTAL HYGIENIST IN PRIVATE PRACTICE.

The service of the dental hygienist in the private offices of graduate dentists is quite apparent, and much of the detail given under Dental Prophylaxis applied directly to this particular field of service. The

following system is offered as one that has been found to be practical and productive of splendid results.

A System for Prophylaxis in Private Dental Practice.—First, a new patient is given two appointments, a week or ten days apart, with the dental hygienist, for a thorough instrumentation and polishing of the teeth. At the end of the first sitting he is supplied with a tooth brush, dentifrice, floss silk and lime-water for a mouth wash, taken to a wash bowl and taught how to properly brush teeth and gums, and given full instructions in the home care of the mouth. As it is now realized that a visual examination of the mouth is very superficial an appointment is reserved for the radiographing of the entire mouth. At the end of the second sitting, one-half hour is reserved for him with the dentist for a thorough chart examination of the mouth and diagnosis of the radiographs. Appointments are then arranged, surgical instrumentation given if necessary, and the teeth restored to a sound condition. At the end of the last appointment the dentist gives the patient another thorough prophylactic treatment.

The patient is then put on a list and sent for each month for a treatment by the dental hygienist. At the end of six months he again goes into the hands of the dentist for an examination of the teeth and gums and a surgical instrumentation if necessary. If the condition of his mouth warrants, the interval between the treatments is now lengthened to six weeks. At the end of the next six months he again goes through the dentist's hands and if good mouth health is attained his name is placed on a two months' list and he is given treatments by the dental hygienist at these intervals, going into the dentist's hand for every third treatment, or once in six months. Patients whose teeth are very susceptible to dental caries, such as children and young people, should be retained on the monthly or six weeks' list.

When the patient's mouth has been put in order and his name placed on one of the lists to be sent for at regular intervals, his name is also entered in the appointment book against the date when his next appointment for a prophylactic treatment falls due. A week previous to this date the patient is notified of the appointment by means of a return card system. This consists of an appointment card bearing the name of the patient and date and hour of his appointment, a return card bearing the same date, and a stamped return envelope. If the date designated proves convenient, the patient signs the return card and returns it in the enclosed envelope and the appointment is checked in the appointment book. If not convenient, a new appointment is made. The various lists of patients—monthly, six weeks, and two months—are kept by means of a card index file. In the writer's practice this system has been compulsory, and has shown very favorable results in the prevention of dental caries and pyorrhea alveolaris. It may also be mentioned that the system has proved to be a financial saving of 60 per cent. to the patients.

HOSPITALS AND SANATORIUMS.

The relation of pathological mouth conditions to systemic diseases is now so definitely known, that hospitals and sanatoriums will be forced to establish a dental division for the radiographing, diagnosing, and sanitation of the mouths of all patients. The sanitation of the mouth will necessitate the services of dental hygienists who can operate at the bedside, if necessary. Such a procedure is already being followed in some hospitals and sanatoriums with most gratifying results.

INDUSTRIAL DENTAL CLINICS.

One of the most important branches of dental hygiene is that which may be provided for the great working classes who need sound teeth for good health, but for whom, until the present time, there has been no provision in dentistry. These are the people who constantly suffer from systemic disturbances due to diseased teeth, yet scientific dental operations are out of their reach. Fortunately preventive dentistry and education for mouth health can be placed within the reach of all. The economic value of educational, preventive and diagnostic dental clinics in connection with large industries has been shown to be the most fruitful form of welfare work for employees.

A working plan for the industrial clinic is suggested as follows: The size of the corps is dependent upon the number of employees in the industry. A unit for one thousand employees should include one dentist, two dental hygienists and a radiographer. The service is limited to prophylactic treatments, instructions in the home care of the mouth, visual and radiographic chart examinations of the entire mouth, and the relief of pain. When the condition of the mouth is charted, a copy is given the patient, and he is advised to visit his own dentist for the elimination of mouth infection and for restoration of lost tooth structure.

The serious illnesses of many valuable employees could thus be prevented, and industries would find such a welfare clinic a very profitable investment.

MUNICIPAL DENTAL CLINICS.

High grade professional service, whether it be medicine, dentistry or law, must be considered as a luxury to the great mass of wage-earning people in cities, and one which they cannot afford. This is especially true of good dentistry. Cheap dentistry is apt to be more harmful than beneficial, for if the operations on the teeth are performed hastily and in an unscientific manner, serious complications may develop within the body, due to bacteria gaining entrance through the roots of the teeth or through the soft tissues which surround them.

There are hundreds of families in cities whose income is not sufficiently large to afford the services of a good dentist and yet they

would like to save their teeth if possible. Decayed and diseased teeth produce much sickness and lower the efficiency and endurance of the workers. This becomes a serious health problem and must be met in a practical manner. Charity, which gives something of value for nothing, is not conducive to character building or good citizenship, and he who accepts it should be in desperate need of aid.

When the administrators of municipalities realize these facts they will establish municipal dental clinics accessible to the wage-earner and his family, especially the children. It would not be the intention of such a clinic to give free dental service, except for the relief of pain to those who are too poor to pay for it, but to establish a clinic where first-class dentistry might be secured at a very moderate cost and be within the means of all whose incomes are too small to enable them to go or to send their children to a dentist in private practice, a movement to help those who are willing and anxious to help themselves.

The dental hygienist has her field of service in this type of relief and repair clinic, where she may restore unsanitary mouths to a clean and wholesome state by operative procedure as well as education in home care.

EDUCATIONAL AND PREVENTIVE DENTAL CLINICS FOR SCHOOL CHILDREN.

The efficiency of dental hygienists in carrying out educational and preventive measures as a part of the school curriculum has been demonstrated for six years in Bridgeport, Connecticut, and it is felt that the results secured would be of sufficient interest to warrant the following detailed report of this work.

REPORT OF FIVE YEARS OF MOUTH HYGIENE IN THE PUBLIC SCHOOLS OF BRIDGEPORT, CONN.[1]

By Alfred C. Fones, D.D.S.

In presenting a report of the findings of a five-year demonstration of an educational and preventive dental clinic in the first five grades of the public schools of Bridgeport, Conn., it is interesting to review the reasoning and deductions by which the plan was perfected. Previous to the establishment of the clinic in 1914, a paper entitled "A Plan that Solves the Fundamental Problem in School Hygiene," was read by Dr. Alfred C. Fones, of Bridgeport, Conn., before the Fourth International Congress on School Hygiene, in Buffalo, August 26, 1913. In it the author summed up in a short article the physical status of the average school child and the problem of the unsanitary condition of his mouth, and evolved a plan for its solution. At that

[1] Read before the Convention of the Connecticut Dental Hygienists' Association, Bridgeport, Conn., May 24, 1919.

period little was known of focal infections, which have proved to be a greater evil than anything yet recognized as traceable to decayed teeth. The paper makes a logical introduction to this report and is presented in full as follows:

Dr. Fones' Plan Proposed in 1914.—"To analyze the subject of hygiene for the uplift and betterment of the children in our public schools, we must determine what are the main factors existing at present that act as a detriment to proper development and also as the chief cause of illness in child life.

"The large number of papers presented at this congress, covering so many phases of the subject, merely proves that we must reach a conclusion, first as to where we should concentrate our energy, and then one step at a time eliminate the most conspicuous evils that beset the school children of our country.

"If our large steel plants and rolling mills were obliged to reroll from twenty to thirty-five per cent. of their stock, it would not take them very long to find out what was the matter. No business nowadays could stand such a high percentage of loss in doing its work over again.

"In our public schools throughout the country it is a fair estimate to say that the percentage of grammar school children who are reviewing their grades will range between twenty and thirty-five per cent. In a majority of the cities the average would be nearer the latter figure. What is the matter? Is it our system of teaching, crowded schools, poorly lighted or ill-ventilated buildings, or is the chief cause to be found in the material itself—the child?

"Let us examine the average boy of ten years of age and see what we find. Face, ears and nose unclean, hair unkempt, hands grimy and finger-nails dirty. Shoes splashed with dry or wet mud, clothes soiled, and an odor percolating through the atmosphere to excite suspicion that his little body has not been washed for some time. His eyesight may be good and yet it may be defective. If his face is washed it may disclose a color that is lacking in the bloom that a boy of ten should have.

"If otherwise his body appears normal we ask him to open his mouth. If his external appearance troubles us, his internal appearance would shock us. Here we find teeth covered with green stain; temporary and permanent teeth badly decayed, possibly fistulae on the gum surface showing outlets for pus from an abscessed tooth or teeth, and decomposing food around and between the teeth. Why examine the child any further? Here at the gateway of the system is a source of infection and poison that would contaminate every mouthful of food taken into his body. With decomposition instead of digestion taking place in the alimentary tract, it is no wonder that the child suffers from an auto-intoxication which produces eye-strain, anemia, malaise, constipation, headaches, fevers and many other ailments.

"Such a mouth is an ideal breeding ground for germ life, and a child with such a mouth is far more susceptible to infectious diseases

than one whose teeth are sound and kept free from food débris. Suppose at the entrance of our cities such a rank condition existed. How long would it be before disease and sickness would be swept in among the inhabitants? This boy described is but duplicated in the girl of ten. Decayed teeth constitute the most prevalent disease known. It is difficult to find two children out of one hundred with perfectly sound sets of teeth. In a thorough dental examination of five hundred and fifty school children in the town of Stratford, Connecticut, but one child was found to have a set of teeth free from decay.

"Look over the reports of the medical inspectors in the public schools who have made but a glancing examination of the mouths, and you will find that decayed teeth outrank all other physical defects combined.

"Therefore we must deduce from our analysis of school hygiene that the most conspicuous defect of the child is the unsanitary condition of his mouth. Like a pig pen or garbage drain, slowly seeping its poison into the brook, which, flowing into the reservoir, contaminates the water supply to a city, so do the products of abscessed and decayed teeth with decomposing food slowly but surely poison the human system. Such mouths and teeth breed disease. Such children cough and sneeze millions of germs made virulent and active in an ideal feeding ground. And then again the teeth as a crushing and masticating machine are frequently ruined by the time the child has reached twelve or fourteen years of age. It is true that they can limp through life with this dreadful handicap, the same as an automobile can climb a steep hill on three cylinders, but you can rest assured that the child with a wrecked mouth at fourteen is traveling on his second speed until he reaches thirty-five, and from there he drops into his low gear to finish the journey in a slow and uncertain state. It is true that many have lived to a ripe old age with unclean mouths and wrecked teeth, not on account of such conditions, but in spite of them.

"If it be conceded that the most unhygienic feature of child life is its mouth we then come to the problem—how can we establish clean mouths, sound teeth and the tooth-brush habit? To try and fill the teeth of the children in our public schools is a noble charity, but an endless chain. Like an immense flood, decayed teeth have spread over the civilized world to such an extent that hardly one-tenth of the population of a country such as ours could find a sufficient number of dentists to fill its teeth. I believe it to be a conservative estimate to say that the children found in the first five grades in our public schools would average not less than six[1] good-sized cavities in their teeth. If you will but figure out how many children there are in your city in the first five grades, you can roughly estimate the immense amount of work there would be for a corps of dentists to cope with such a task as filling their teeth. This would not mean merely plugging a hole in a piece of ivory; it means the painstaking work of a dental operation on live tissue.

[1] Later findings showed seven—plus.

"But let us assume that it is possible to fill these teeth and save them for the time being, how are we to prevent a re-occurrence of decay as well as to check the flood with the children coming into the schools in the primary grades each year? Surely every dentist knows that the tooth brush alone will not stop it, and every dentist also knows, as well as the parent, how difficult it is to induce children to properly brush their teeth and take care of their mouths as they should. Would it not be better to evolve a system for the prevention of dental decay and the establishment of clean mouths than try to cope with the hopeless task of filling the thousands of decayed teeth? I am heartily in sympathy with the scheme that every city should have a dental clinic for the school children for the relief of pain, and I believe it is inhuman in this twentieth century to allow the poorer class of children to suffer as they do from toothache. But let us draw a line on the conditions as they exist today, and I would present this plan, partly suggested by Dr. Ottolengui, of New York, for your consideration.

"It is a clinical fact that fully eighty per cent. of dental decay can be prevented, if monthly or even bi-monthly surface polishing of the teeth with orange wood sticks and fine pumice can be systematically followed. These treatments, of course, to be augmented by the faithful and correct use of the tooth brush, floss silk and lime-water as a mouth wash.

"Suppose it were possible to start a year from this September and place in our schools trained women who would confine their efforts the first year to the children in the first grade. These women to be trained and educated as hygienists who would be competent to give each child a surface treatment of the teeth once a month; each woman to have the supervision, to start with, of two hundred children; these children in the first grade to be taught the proper use of the tooth brush, mouths inspected daily for cleanliness, and no child permitted to enter the class room who had not brushed his teeth. Hands and face to be clean and hair combed. Bodily cleanliness also insisted upon and efforts made to secure the coöperation of the parents. Talks in the class room as well as the use of the stereopticon in the assembly room would greatly aid in securing the desired results. These hygienists could also be of great aid to the medical inspectors. At the end of the year they would follow the children into the second grade and a new corps of hygienists would enter the first grade with the new pupils; this to be repeated for five years, until the first corps of women were caring for their children in the fifth grade. It is doubtful if it would be necessary to carry this work beyond the fifth grade, as the child would be cared for through the most susceptible period for dental decay.

"Now what would such a system mean to the children? It would mean that from the first day that the child entered school it would be taught cleanliness. That when the first permanent tooth entered the mouth it would be under the supervision of the hygienist, who would teach the child how to keep it clean and who would also aid with the

monthly polishing. It would mean that during the first five years of school life habits of cleanliness would be established that would mold these boys and girls into new types of men and women. Fully three-quarters of the diseases incident to child life would be eliminated. With an additional knowledge of food values and how to properly masticate their food instead of bolting it, the main factors for hygiene would be covered.

"Booker Washington once said: 'If I can teach the colored man the gospel of the tooth brush, I feel that I can make a man of him.' Those of you who see but little of children can hardly realize what an uplift and different point of view there comes with a clean mouth and polished teeth. It is interesting to see a child whose teeth have been polished and a washbowl instruction given in the use of the tooth brush, gradually change in general appearance regarding cleanliness. I have known them in a few weeks to choose a new set of companions because the old friends no longer looked attractive to them. No one ever saw a rowdy with a clean mouth, for cleanliness breeds refinement. The proper food supply to the body and cleanliness are the two main foundation pillars for health, and these must be taught and practised before we can hope to obtain satisfying results in the betterment of child life. There is much in life worth while besides teeth, but I know of no one factor that is more conducive to health than sound teeth and a clean mouth.

"The question may be asked: How are we to educate these women to be dental hygienists? In every large city there are men in both the medical and dental professions who are competent to establish a lecture course for this purpose. The necessary training in the prophylactic treatment of the teeth would, of course, be given by dentists. Both of these professions are anxious to aid in any cause so worthy, and I believe they would willingly give their time and knowledge to start such a movement. It is impossible in this paper to give the details concerning the education of these women and their full duties in the schools, but enough has been stated to permit those in charge of our public school systems to consider the proposition in a general way and determine if this plan is a solution of the main problem regarding school hygiene."

Inception of the Bridgeport Experiment.—For four years previous to 1913, strenuous efforts had been made to interest the city officials of Bridgeport to provide funds for an educational and preventive dental clinic in the public schools. At last five thousand dollars was apportioned to the Board of Health in order that a demonstration might be made to prove the value of a mouth hygiene campaign conducted on an educational and preventive plan.

With the possibility of this movement being a powerful aid in the prevention of dental decay, infectious and communicable diseases, eighteen prominent educators in the East agreed to come to Bridgeport and give their services gratis to educate a corps of women to be known

as dental hygienists. The course was started in the late fall of 1913, and in June, 1914, the first class of dental hygienists was graduated.

The Board of Health appointed a committee of four dentists and one member of the Health Board, a physician, to establish the system in the schools. Eight dental hygienists and two supervisors were chosen, and in September, 1914, the work was begun for the first and second grade children.

First Hygienists at Work in Public Schools.—There were four distinct parts to the system. First, the prophylactic treatment or the actual cleaning and polishing of the children's teeth and chart examination of the mouths. Second, tooth-brush drills and class-room talks. Third, stereopticon lectures for children in the higher grades; and, fourth, educational work in the homes by means of special literature for parents. The prophylactic treatment consisted mainly in the thorough cleaning, by means of orange wood sticks in hand polishers, of every surface of every tooth. This meant that the dental hygienist would remove all stains and accretions from the surfaces of the teeth, and especially the mucilaginous films known as bacterial plaques, which are the initial step of dental decay. The treatments were given in the schools, the equipment being portable and adapted to almost any location. Every child received the same treatment, regardless of the financial status of the parent; in short, this preventive system was incorporated as part of the school curriculum. Some parents objected, thinking the work was a charity, but with a better understanding of it the objections were soon withdrawn.

The tooth-brush drills were given by the supervisors, and a method of mouth brushing was taught for use in the home. No attempt was made to use water and a dentifrice in the class room, as this would prove to be too mussy. Class-room talks concerning foods, cleanliness, etc., were part of the drill. The total number of children examined and treated in the first and second grades the first year was 6768. On the first examination less than ten per cent. were brushing their teeth daily. About thirty per cent. claimed that they brushed their teeth occasionally, while sixty per cent. were frank enough to state that they did not use a tooth brush. Ten per cent. of the children were found to have fistulæ on the gums, showing the outlets of abscesses from the roots of decayed teeth, and they averaged over seven cavities per child. It was shocking to find the mouths of these children ranging from five to seven years in this deplorable condition, and it was appalling to contemplate the conditions that would exist in these mouths as the children grew up. It presented very interesting material to work with.

It will take a long period of public education before the mouths of the incoming children to our first grade will show any great degree of improvement. From birth to five or six years of age they are entirely under the home influence and are permitted to eat foods, especially sweets, that are conducive to decay, and mouth cleanliness is not compulsory. Slowly but surely the public school education will seep back

into the homes, and with the aid of the older children and pamphlets it is our hope that eventually the mouths of these children will present a much improved condition.

Corps of Hygienists Increased. In September, 1915, six additional hygienists were added to the corps to advance the work to cover the first three grades. This gave a sufficient number of workers until 1917 when six more were added, so that this care could be given to all the children in the first five grades, numbering about 15,000.

In January, 1918, the parochial schools petitioned the Board of Health and also the Board of Apportionment to have this system extended to them as a health measure. This petition was granted and in September six more hygienists were added to the corps for this purpose, making twenty-six in all. At the present time these women have under their care the mouths of nearly twenty thousand children in the first five grades.

We have also employed three women dentists, who are filling the small cavities in the first permanent molars for the children in the first and second grades. Many of these children, on entering school, have small cavities developing in these most important teeth, and in order that all the children may start on an equal basis in the future prevention of dental decay of the permanent teeth, all are eligible and are encouraged to have these small cavities filled.

Examination of Fifth Grade Children.—In order to prove definitely the value of education and prevention, it was necessary to have data of the condition of the mouths of children in a higher grade who had never had the advantage of prophylactic treatments, tooth-brush drills, and education in mouth hygiene. The children of the fifth grade were chosen as the control class, and this report will present the comparison of their mouth conditions with the present fifth graders, who have had prophylactic treatments and education in mouth hygiene for the first five years of their school life. They have had no repair work provided for them and the educational side has been three-quarters of the work of the dental hygiene corps.

In making this demonstration it was not our expectation to make a startling reduction in the percentage of dental decay, the main object being to show up the pernicious mouth conditions prevailing among school children and to prove the value of prevention and education in mouth hygiene for great numbers of children in preference to extensive repair clinics, with no effort to eliminate the source of the trouble. It would, of course, have been ideal to have had the two types of clinics and to have put the children's mouths in sound condition, but funds were not available for this purpose, and the excellent report shown is merely the result of education and prevention.

For the purpose of securing this data a complete record chart has been maintained of the condition of every child's mouth at each successive treatment, and the following figures were obtained by comparing the average number of cavities per child in the fifth grade of a given

school with the average secured from the same grade of the same school several years ago. The demonstration was conducted in thirty schools and this year twenty thousand individual children received this treatment and education.

Dental Caries.—Following is the percentage of reduction of cavities in the permanent teeth of the fifth graders in these schools:

The highest was Barnum school, which showed a reduction of 67.5 per cent.

The following five schools were over 57 per cent.: Huntington Road, Kossuth, Prospect, Grand and Sheridan.

Two schools, Maplewood and Franklin, showed over a 50 per cent. reduction.

Three schools, Summerfield, Lincoln and Staples, were over 40 per cent.

Washington, Wheeler and Black Rock were over 30 per cent.

Newfield, Garfield, Hall, Jackson and Shelton were over 25 per cent.

Bryant, Elias Howe and Madison were over 20 per cent.

Those over 15 per cent. were Waltersville, Jefferson, Longfellow, Columbus and Webster.

One school, Read, was below 10 per cent., and two schools, Whittier and McKinley, showed a minus record.

The total average for all these schools amounts to 33.9 per cent.[1]

Although the principals and teachers have given splendid coöperation in many of the schools that have low records, they had to contend with a certain number of children whose home influence was not conducive to any interest in mouth hygiene.

Difficulties Met With.—The two schools which showed a minus record were unfortunate enough to have a number of children who were so absolutely negligent in the care of their mouths that they dragged down what would have been a reasonably good average by three-quarters of the children.

Bridgeport has been one of the most difficult cities in which to carry on a demonstration of this kind. We have a large foreign population of which many parents do not speak English. Being a munition center during the war period, the population increased many thousands, overcrowding the city and schools. The school records showed in the past year that 58 per cent. of the children changed addresses and that the population was constantly shifting. The principals and teachers were occupied with many war duties, such as Junior Red Cross, thrift stamps, Hoover programs, etc. In short, no period could have been more unpropitious for a serious demonstration of this kind.

Aside from this, the value of education and prevention has, with deliberate intent, been put to the hardest possible test. No effort has been made to address or educate the teachers or to enforce coöperation through the office of the superintendent of schools. The supervisors and dental hygienists have been permitted to win their own way, so

[1] Percentage of reduction was 49.6 for 1919-20.

that it might be demonstrated that what was accomplished in Bridgeport could be accomplished in any city.

Reduction of Dental Caries.—We believe that from 70 per cent. to 80 per cent. of dental caries can be eliminated through the public school system by the incorporation in the school curriculum of a definite health program, making hygiene one of the requisites for promotion. This would insure the coöperation and interest of the child, teacher and parent.

The elimination of dental decay is so dependent upon factors other than cleanliness and education in mouth hygiene that it is surprising to note the large reduction in many schools. The most important factor is that of diet, and coöperation in this matter can be secured only after many years of education. The correct feeding of a child from birth to twelve years would in itself partially, if not wholly, eliminate dental decay. The education of mothers regarding the feeding of children after they reach an age when milk does not meet the requirements of the body is very essential, but it is necessarily slow, and little coöperation can be secured at this time. The most important factor would be the elimination of free sugar from the diet. This seems radical to the vast majority of our people who consume ninety pounds of sugar per capita per year and look upon it as a food and a necessary part of the diet. This is an erroneous idea, since nature has provided all the sugar that the body requires in various common foods, as milk, fruits, some of the vegetables, etc., besides providing that all starchy foods, such as potatoes, bread, macaroni, rice, etc., be changed into sugar in the digestive process.

The excessive consumption of free sugar is undoubtedly the cause of exceedingly poor teeth among the English, French and American peoples.

It is not hard to imagine that a very large percentage of children are constantly laboring under a handicap of faulty feeding which in turn produces a long line of other handicaps, such as malformed jaws, decayed teeth, underdevelopment, malnutrition, etc., while the most normal conditions could be secured by correct diet and cleanliness.

Malocclusion.—Aside from dental decay, the most noticeable defect in the mouths of the school children is lack of proper relationship between the jaws and teeth, or malocclusion. The symmetrical development of the brain case and the bones of the face, as well as good digestion, is dependent upon a perfect masticating machine. It was astonishing to note that malocclusion was present in 98 per cent. of all the children examined in the past five years. This deplorable condition could be remedied to a great degree by the feeding in early childhood of the hard, coarse foods requiring pressure to thoroughly masticate, and by the prevention of any pernicious habits, such as thumb sucking, the use of pacifiers, mouth breathing, etc. Undoubtedly adenoids would be prevented to a marked degree if the roof of the mouth could be broadened and lowered by such pressure exerted in chewing. This

would permit of wide nasal cavities that would be conducive to nose breathing and proper functioning of the nasal passages.

When but two per cent. of our school children have regular teeth it adds to the difficulty of eliminating dental decay, since irregular teeth offer the greatest opportunity for the formation of cavities and render the thorough cleansing of the mouth very difficult.

Retardation.—Our modern city school systems all have a smaller or greater per cent. of retarded pupils. The test of the success of any city school system at any given time is not whether there be at that time a large percentage of retarded children, but whether a decided trend can be traced toward an increase or decrease in percentage of such retarded children.

Retardation is a serious matter from the standpoint of the pupil, the parent, the teacher, and the community. Retardation means reëducation, and this in turn means the application of public funds for repeating the operation. In the figures given below the very liberal standard adopted for retardation permits the child to be two years older than his grade would warrant and still be classified as regular. Those who are more than two years older than entering the first grade at the age of five would indicate, are classified as retarded.

The statistics at hand in the office of the Board of Education are not available year by year, but two general surveys have been made—one during September, 1912, and the other in November, 1918. These surveys, called the Age-Grade Report, immediately precede the opening of our work and occur near the close of the first five-year periods and so offer rather unusual opportunity for inference as to the effects produced. Reduced to a percentage basis, the changes that have taken place in the matter of retarded pupils in the grammar schools are summarized in the following table:

PERCENTAGE OF RETARDED PUPILS.

Grade.	September, 1912. Per cent.	November, 1918. Per cent.	Drop in retardation.
I	16.5	8.1	51
II	37.0	15.3	58
III	53.0	24.7	53
IV	59.5	31.7	47
V	61.0	33.1	45
VI	54.0	30.4	44
VII	39.0	19.3	50
VIII	27.0	12.5	54
Average	40.0	20.1	50

This reduction of retardation by 50 per cent. is a really wonderful change to be accomplished in any school system in a period of five or six years. Few people have realized the cost in money—which is only one of the evils of retardation—of the reëducation of our retarded children. By actual figures the following statement holds true:

Cost for reëducation in Bridgeport, 1912, equals 42 per cent. of entire budget.

Costs for reëducation in Bridgeport, 1918, equals 17 per cent. of entire budget.

One has only to consider the financial side to recognize that any reduction in retardation is an accomplishment devoutly to be sought through all legitimate means. Bridgeport has been moving distinctly forward in this matter.

That this change has been a vital one to the self-respect of the pupils and in the advance of the moral conditions of the normal children is easily realized when one stops to consider the change in the location in our grades of the pupils fourteen years old and over that has come about during this same 1912–1918 survey.

PUPILS FOURTEEN YEARS OLD OR OVER.

	I.	II.	III.	IV.	V.	VI.	Grades.
Sept., 1912	13	17	58	107	169	212—4.0 per cent. of elementary pupils.	
Nov., 1918	0	0	11	35	109	155—1.5 per cent. of elementary pupils.	

Nor does this tell the entire story. As a result of the 1912 survey the following statement is made: "During the fifteen months ending last December, 1356 children in Grades II to VI, all of the retarded class, and over fourteen years of age, left school to go to work." Examination of the records of the State Examination Board reveals the fact that during the same period of the last year less than 300 pupils, all of whom came from grades V and VI, received working certificates.

Another effective proof of the great forward movement that has taken place in the lower grammar school grades is submitted in the following form:

In 1912, 60 per cent. of all the children registered in the grammar schools were below the fourth grade, while in 1918 but 50 per cent. were below the fourth grade. Similarly, in 1912, 85 per cent. were below the sixth grade, and in 1918 but 78 per cent. were below the sixth grade.

Without taking into consideration the physical condition of the children, educators claim that the three major factors producing retardation are:

1. Overcrowded class rooms.
2. Uninteresting and unsuitable courses of study.
3. Unqualified teachers.

Regarding the first, the following situation is interesting to note:

Average pupils per teacher, 1912, 38.

Average pupils per teacher, 1918, 40.

The cause for reduction in retardation does not lie here. This has been rather a hindrance to its reduction.

In regard to the course of study, a very effective reorganization of the subject matter in arithmetic, geography, language and history has been made within the past three years, and that, no doubt, has had a large influence in the matter of producing an interest in their work

on the part of the pupils. This must have had a very potent influence in reduction of retardation.

With respect to the matter of teachers, the personnel and chief source of supply in Bridgeport remains about the same as in 1912. Our City Normal School produces most of the additional teachers placed in the grammar school grades. A well-arranged study program has been introduced for teachers requiring application to approved courses for advancement in salary, and this has probably resulted in a more wide-awake teaching body than we had in 1912.

These changes, however, could hardly have effected on their own account the phenomenal reduction in retardation that has occurred in the period stated. The most sanguine advocate would hardly take the ground that such a remarkable change had been effected simply by the introduction, late in the period under discussion, of modified courses of study. There must have been other contributing factors with a large influence.

Our dental work has called attention to the necessity of taking into account the child's well being. For the greater part of the period of this demonstration this work stood practically alone in any progressive health movement. During the latter part it has been aided by the City Health Department with an enlarged force of nurses, and at the present time the Superintendent of Public Schools is planning a Health Program to be introduced into the grammar schools in September as a big, serious effort in recognition of the fundamental physical basis for all education. He says: "The dental clinic has been without question a great factor in the health of the children, and, therefore, must have been one of the factors in reducing the condition of retardation, which figures show have been reduced 50 per cent. since November, 1912. Our promotions now are better than normal."

With all these facts balanced it seems only fair to conclude that while the work of the Dental Division in the public schools is somewhat intangible, it has had a very marked effect upon a more normal promotion of children, since the change cannot be explained by other factors.

Communicable Diseases.—The forms of communicable diseases where mouth hygiene could play an important part for prevention are those which involve the respiratory tract or find ingress to the body through the mucous membrane lining the mouth, throat and nares. The resistance to bacterial invasion may not be determined entirely by the contents of the blood, but by the tone and resistance of the cells of the individual tissues on which the bacteria may lodge temporarily. One bacterium does not produce a disease. It is only when the environment proves favorable for their propagation and the production of large numbers that infection occurs.

Any continuous effort that has for its object the removal of dead animal and vegetable matter, such as food débris, from all the surfaces of all the teeth, the stimulating and keeping up of the tone of the membrane lining the mouth, and the reducing of the number of bacteria in

the mouth to a minimum, must act as a powerful preventive by aiding the tonsils, the soft palate, and the pharynx to maintain a normal and healthful condition.

Conversely, those mouths which are neglected and contain decayed teeth with decomposing food, red and congested gums, enlarged tonsils and a palate and pharynx covered by an irritated and partly congested mucous membrane, present an ideal field for the lodgment and incubation of the pathogens. How much of the communicable diseases that gain ingress through the mouth will finally be eliminated from child life in our public school system by an enforced system of mouth hygiene is still a question, but all evidence seems to show that a clean mouth with sound teeth is the one most important factor for prevention.

Up to a short time ago we had no tangible records in the Department of Health that pertained to communicable diseases in the children of our public schools, whereby comparisons could be made from year to year of an increase or decrease in the numbers of these diseases. It is, therefore, impossible at the present time to show what obtained in the schools four or five years ago in comparison with what obtains today.

Out of the death-rates from all causes in this city we have been able to find records of three diseases which are so common among children, namely, diphtheria, measles and scarlet fever. These are figured on a basis of per 100,000 population, and show the following:

	1914.	1918.
Diphtheria	36.6	18.7
Measles	20.0	4.1
Scarlet fever	14.1	0.5

From the death-rate tables the general inference must be that the percentage of communicable diseases is gradually decreasing.

Influenza.—The record of Bridgeport during the great scourge of influenza was an exceptionally good one. The deaths amounted to 5.2 per cent. per 1000 population. This is the lowest record we have been able to find as yet in cities approaching the size of Bridgeport.

The City Health Officer took the stand that since influenza was spread by the expelled secretions of the mouth and respiratory tract, the greatest means of suppressing this disease would be the knowledge of children and adults of the dangers of coughing, sneezing and spitting. He inaugurated an intensive educational campaign in theaters, motion-picture houses and at all public gatherings regarding the contraction and spread of influenza. During this period he stated that an intelligent background for this education had been prepared by the regular work of the dental clinic in instructing children individually and in distributing thousands of hygiene pamphlets in the homes for the enlightenment of the parents, regarding common ways of spreading diseases and the hygiene of prevention. Five years of such education in conjunction with mouth hygiene, played an important part in giving our citizens, as a whole, a more intelligent impression regarding contagious

diseases, and the health officer and his co-workers had a more enlightened public to work with. He states further that "the most important side of this work is the educational opportunities afforded the hygienist. She is an important factor in raising the sanitary intelligence of the community, which is, after all, the object for which modern health workers are striving."

Summary.—To summarize: we have found that in schools or districts where little or no attention has been given to mouth hygiene it is difficult to find three children out of a hundred with teeth entirely free from dental caries. We have also found that, owing to this lack of education and enlightenment, not more than 10 per cent. of the children were using a tooth brush daily. That malocclusion, which means that the teeth are out of their normal position in the mouth, thus preventing their striking the teeth in opposition, as nature intended they should strike, is as common as dental caries.

That retardations are greatly influenced by the toxic effect produced by numerous bacteria in unclean mouths and in diseased and pulpless teeth.

Although properly tabulated records of the Board of Health do not date back far enough to show facts and figures regarding communicable diseases, yet we have sufficient data which, on close observation, convinced us that mouth hygiene is to be a very powerful factor in the restriction of communicable and infectious diseases in childhood.

The Dangers from Focal Infections.—For years the dental profession has appreciated the toxic influence on the system of unsanitary mouths and the dangers presented to the individual by such mouths incubating hundreds of millions of bacteria. It has been apparent that among adults infections of the system were taking place around the necks of the teeth, through the inflamed and diseased tissues which support the teeth, but it was not until the *x*-ray revealed the infected areas at the ends of the roots that dentistry appreciated to the utmost the seriousness of neglected mouths and pulpless teeth. These apical infections are difficult for the layman to understand, because they produce no soreness, no pain, no inflammation, no pus. They are caused by a type of bacteria known as the streptococcus viridans, which is quite friendly and harmless in the mouth, and which belongs to the saprophytic class. When a pulp dies in a tooth these bacteria commonly gain ingress through the root canal of a tooth to the apex, or out into that area where the tissues are bathed with the body juices or serum. In this new environment they gradually change their nature and instead of securing their food from dead animal or vegetable matter, such as they found in the mouth around the teeth, they are now enabled to obtain their nourishment from the blood serum which surrounds them.

Action of the Bacterial Toxin.—Like all bacteria, they exude waste matter from their bodies, which is a toxin; but these bacteria, being of low virulency, do not create as vicious a toxin as many of the pathogens. However, the toxin is of sufficient irritation to cause the osteo-

clasts to break down and absorb the bony wall around the end of a root of a tooth, which destruction of bone may be readily seen in the *x*-ray picture. This toxin is absorbed by the lymphatic vessels and its presence in the blood undoubtedly excites the production of an antitoxin which neutralizes this poison and may successfully control it for years. As long as the individual maintains normal health and the antitoxin is produced in sufficient abundance to act as a neutralizer these infected areas remain harmless.

Action of the Bacteria.—The longer these bacteria live in this environment of serum, the more aggressive they become, and although they do not seem to take on the virulency of a true pathogen, yet when the bodily resistance becomes lowered they make the trip from the end of the root of a tooth, through the lymphatics and into the blood stream. These microörganisms vary in their affinity for certain tissues, some finding the valves or the lining membrane of the heart the most favorable, others the kidneys, while still another class may locate in the joints. In fact, there seems to be no limit to the organs or tissues in which the various members of this family may find a congenial habitat. Having once located in a favorable environment in the body, they again form colonies, and, exuding their toxin, so poison and lower the activities of the cells of the tissues upon which they are located that these cells eventually find it impossible to properly functionate and carry on their individual work, and we have the beginning of a diseased tissue or organ of the body. It is because the action of these saprophytes is so slow and possesses such a low virulency that the medical and dental professions at large have failed to grasp, as yet, what a terrible menace these focal infections are to human life, and again the sad fact is that they are so exceedingly common, for nearly every adult has one or more pulpless teeth in his mouth, and nearly every adult will show under the *x*-ray affected areas above such pulpless teeth. If the resistance remains high they may carry such infection for ten—yes, twenty—years, but a colony of these bacteria living within bone tissue and exuding their toxin into the blood stream will sooner or later create systemic disturbance, which, if not taken in time, will mean the beginning of the end. Recently the writer has been demonstrating for his own satisfaction whether the streptococcus viridans found in these infections had developed the nature of a pathogen. In a number of cases cultures made from infected roots proved fatal within forty-eight hours after their injection into mice.

With these thoughts in mind, it must, in the near future, be recognized that a toothache is a calamity, for most toothache means that decay has already reached the pulp, and a dead pulp means danger of apical infection. The best root filling we know of is a live pulp. Therefore, the effort must be made to prevent decay from penetrating deep enough in a tooth to involve a pulp.

When these various pernicious mouth conditions are more fully understood as the one greatest factor for producing disease, medicine

will then acknowledge dentistry as its greatest specialty. Also, from a prophylactic standpoint, will mouth hygiene be considered the most important branch of general hygiene.

Importance of a Health Program in Public Schools.—It must soon be apparent to educators in our public school system throughout the country that a health program of considerable magnitude is essential in these schools for the prevention and correction of remediable physical defects among the children. These defects, if neglected, may eventually be the cause of the child's disability, and in later life can have a detrimental action, morally, mentally and physically. No longer can they specialize on mental development and leave the body of the child entirely in charge of home influence. The findings of our draft boards have conclusively shown us the fallacy of such procedure. If we study the following table submitted by General March, of the U. S. Army, compiled from the data collected by the draft boards, we will see that there has been dire neglect in the supervision of the child's body:

"The effectives at ages twenty-one to thirty, for approximately ten million men, in 1917 were:

	Per cent.
21 years	46
22 "	43
23 "	39
24 "	35
25 "	32
26 "	29
27 "	27
28 "	26
29 "	23
30 "	22

The effectives at the ages thirty-two to thirty-six drop to less than 15 per cent."

Special attention is called to the rapid accumulative effect of physical disability after the adult passes thirty years of age.

Dr. Osler has stated that the diseases of which we die in adult life are those which are contracted or made possible in early youth.

The figures in General March's table would seem to corroborate statements repeatedly made by pathologists that after thirty years of age physical resistance to disease is on the decline, and in the vast majority of people can only be maintained in middle life by healthful habits and freedom from physical defects that permit bacterial invasion into the system.

This demonstration has provided sufficient data to convince us that every community, sooner or later, must adopt some plan, preferably one of prevention, to establish clean mouths and sound teeth for school children.

We know of no one movement, from the health standpoint, that would be more beneficial to the nation at large than a serious educational campaign to eliminate dental caries, as far as would be possible. There is much in this work that cannot be measured in figures, especially

the moral uplift which comes to the individual when he is taught the importance of cleanliness and a wholesome respect for his body.

The prevention of diseases such as syphilis, tuberculosis, dental caries, etc., will come, not through any specific form of medication or treatment, but chiefly through education and enlightenment. Books, pamphlets, articles in magazines and newspapers, all are of great value in disseminating knowledge; but for actual tangible results in eventually reaching all members of a community, nothing will compare with thoroughly spreading such knowledge among the children in our public school system.

The results, as shown in this report, may be obtained in practically any section of the country, if the hygienists and supervisors in charge of the work are sufficiently educated in their specialty. It must be clearly understood that although the dental corps has been guided in its work, what has been accomplished has been mainly through its own intelligent individual effort and not through any coercion of the teachers by the educational authorities in charge of the school system. This demonstration was conducted along these lines under the least favorable circumstances purposely to prove the real efficacy of prevention. It is our hope that from now on a definite health program will be introduced into our school system in Bridgeport that will give the teachers a greater appreciation of the importance of sound bodies for the children, thus securing a complete coöperation and interest on their part in this most important phase of child welfare.

SCHEDULE OF LESSONS ON MANIKINS.

POLISHING AND INSTRUMENTATION.

First.
- Teaching the four motions—digital, wrist, rigid-arm and rotary.
- Grasp of polishers.
- Direction of procedure for polishing.
- First three divisions of polishing.

Second.
- Fourth, fifth, sixth, seventh and eighth divisions.

Third.
- Ninth, tenth and eleventh divisions and review of entire labial and buccal surfaces of teeth of both jaws.

Fourth.
- Twelfth, thirteenth, fourteenth and fifteenth divisions.

Fifth.
- Sixteenth and seventeenth divisions and review of entire lingual surfaces of teeth of both jaws.

Sixth.
- Beginning instrumentation.
- First two divisions.

Seventh.
- Third, fourth, fifth, sixth, seventh, eighth and ninth divisions.

Eighth.
- Practical examination on polishing.

Ninth.
- Theoretical (half-hour) examination on polishing.
- Review of instrumentation—removal of varnish and plaster from teeth of lower jaw.
- Divisions ten and eleven.

Tenth.
Twelfth, thirteenth, fourteenth, fifteenth, sixteenth, seventeenth and eighteenth divisions of instrumentation.
Eleventh.
Review instrumentation, removal of varnish and plaster from teeth of upper jaw.
Divisions nineteen and twenty.
Use of floss for polishing approximal surfaces and use of brush wheel for occlusal surfaces.
Twelfth.
Examination. Instrumentation (practical) and instrumentation (theoretical).

SYSTEM FOR INSTRUMENTATION.

Division 1. Fig. 166.

Teeth.	Right lower molars, bicuspds, cuspid, lateral and central.
Surface.	Lingual.
Instrument.	No. 18 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	End of third finger between left lower cuspid and bicuspid on occlusal surface.
Motion.	Wrist or rotary.

Division 2. Figs. 167 and 168.

Teeth.	Left lower central, lateral, cuspid, bicuspids and molars.
Surface.	Lingual.
Instrument.	No. 17 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	End of second finger on cutting edge of right lower cuspid or lateral for left lower central, lateral and cuspid.
	End of third finger on cutting edge of lower centrals for bicuspids and molars.
Motion.	Rotary.

Division 3. Fig. 169.

Teeth.	Left lower molars, bicuspids and cuspid.
Surface.	Buccal.
Instrument.	No. 18 Darby-Perry.
Fulcrum-point.	End of third fingers on labial surface of lower incisors.
Motion.	Wrist or rotary.

Division 4. Figs. 170 and 171.

Teeth.	Lower incisors, right lower cuspid, bicuspids and molars.
Surface.	Labial and buccal.
Instrument.	No. 17 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger between left lower cuspid and bicuspid for lower incisors.
	Advanced on incisors for cuspid, bicuspids and molars.
Motion.	Rotary.

Division 5. Figs. 172 and 173.

Teeth.	Right lower molars, bicuspids and cuspid.
Surface.	Distal.
Instrument.	No. 13 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of third finger on cutting edge of lower incisors for distal surface of last molar.
	End of third finger on labial surface of right cuspid and incisors for the balance.
Motion.	Wrist and digital.

Division 6. Similar to Figs. 172 and 173.

Teeth.	Left lower cuspids, bicuspids and molars.
Surface.	Distal.
Instrument.	No. 13 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of third finger on labial surface of lower incisors.
Motion.	Wrist and digital.

Division 7. Similar to Fig. 174.

Teeth	Right lower molars, bicuspids and cuspid.
Surface.	Mesial.
Instrument.	No. 14 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of third finger on labial surface of right cuspid and incisors.
Motion.	Wrist and digital.

Division 8. Fig. 174.

Teeth.	Left lower cuspid, bicuspids and molars.
Surface.	Mesial.
Instrument.	No. 14 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of third finger on labial surface of lower incisors.
Motion.	Wrist and digital.

Division 9. Fig. 175.

Teeth.	Lower incisors.
Surface.	Approximal.
Instrument.	Nos. 5 and 6 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	Third finger on chin.
Motion.	Wrist.

Division 10. Fig. 176.

Teeth.	Right upper molars, bicuspids, cuspid, lateral and central.
Surface	Lingual.
Instrument.	No. 17 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	End of third finger on occlusal surface between left lower cuspid and bicuspid.
Motion.	Wrist.

Division 11. Figs. 177 and 178.

Teeth.	Left upper central, lateral, cuspid, bicuspids and molars.
Surface.	Lingual.
Instrument.	No. 18 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	End of second finger on cutting edge of right upper cuspid.
Motion.	Rotary.

Division 12. Fig. 179.

Teeth.	Left upper molars, bicuspids, cuspid, lateral and central.
Surface.	Buccal and labial.
Instrument.	No. 17 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	End of second finger on labial surface of left upper central and lateral and end of third finger on lingual surface of right upper central and lateral, for molars, bicuspids and cuspid. End of third finger on cutting edge of right upper cuspid for lateral and central.
Motion.	Rotary.

Division 13. Fig. 180.

Teeth.	Right upper central, lateral, cuspid, bicuspids and molars.
Surface.	Labial and buccal.
Instrument.	No. 18 Darby-Perry.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third and fourth finger on chin.
Motion.	Rigid-arm and rotary.

Division 14. Fig. 181.

Teeth.	Right upper molars, bicuspids and cuspid.
Surface.	Distal.
Instrument.	No. 13 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger on labial surface of lower incisors.
Motion.	Digital and wrist.

Division 15. Similar to Fig. 181.

Teeth.	Left upper cuspid, bicuspids and molars.
Surface.	Distal.
Instrument.	No. 13 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger on labial surface of lower incisors.
Motion.	Digital and wrist.

Division 16. Similar to Fig. 181.

Teeth.	Right upper molars, bicuspids and cuspid.
Surface.	Mesial.
Instrument.	No. 14 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger on labial surface of lower incisors.
Motion.	Digital and wrist.

Division 17. Similar to Fig. 181.

Teeth.	Left upper cuspid, bicuspids and molars.
Surface.	Mesial.
Instrument.	No. 14 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger on labial surface of lower incisors.
Motion.	Digital and wrist.

Division 18. Similar to Fig. 175.

Teeth.	Upper incisors.
Surface.	Approximal.
Instrument.	Nos. 5 and 6 Smith set.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Wrist and digital.

Division 19. Fig. 182.

Teeth.	Lower.
Surface.	Buccal, labial and lingual.
Instrument.	Sickle-shaped.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger on cutting edge of incisors.
Motion.	Digital. Draw stroke.

Division 20. Fig. 183.

Teeth.	Upper.
Surface.	Buccal, labial and lingual.
Instrument.	Sickle-shaped.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin; or fist grasp—end of thumb on occlusal surface.
Motion.	Digital. Draw stroke.

Division 21.

Instrument.	Nos. 3 and 4 Harlan.
Use.	For small, hard, tenacious deposits under gingival border.
Motion.	Draw stroke.

SYSTEM FOR POLISHING—LARGE STICK.

Division 1. Fig. 186.

Teeth.	Upper right central and lateral.
Surface.	Labial.
Grasp.	Porte polisher held in fist.
Fulcrum-point.	End of thumb on cutting edge of right cuspid.
Motion.	Digital.

Division 2. Fig. 187.

Teeth.	Upper right cuspid, first and second bicuspids.
Surface.	Labial.
Grasp.	Fist.
Fulcrum-point.	Back of third finger on chin.
Motion.	Rigid-arm.

Division 3. Fig. 188.

Teeth.	Upper right molars.
Surface.	Buccal.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Rotary.

Division 4. Similar to Fig. 188.

Teeth.	Lower right molars.
Surface.	Buccal.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Rotary.

Division 5. Similar to Fig. 187.

Teeth.	Lower right bicuspids and cuspid.
Surface.	Buccal.
Grasp.	Fist.
Fulcrum-point.	Back of second finger on chin.
Motion.	Rigid-arm.

Division 6. Fig. 189.

Teeth.	Lower incisors.
Surface.	Labial.
Grasp.	Fist.
Fulcrum-point.	Thumb or first finger of left hand, depressing lips.
Motion.	Rigid-arm.

Division 7. Similar to Fig. 187.

Teeth.	Left lower cuspid and bicuspid.
Surface.	Labial.
Grasp.	Fist.
Fulcrum-point.	Back of second finger on chin.
Motion.	Rigid-arm.

Division 8. Similar to Fig. 190.

Teeth.	Lower left molars.
Surface.	Buccal.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Rigid-arm.

Division 9. Fig. 190.

Teeth.	Upper left molars.
Surface.	Buccal.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Rigid-arm.

Division 10. Similar to Fig. 187.

Teeth.	Left upper bicuspids and cuspid.
Surface.	Labial.
Grasp.	Fist.
Fulcrum-point.	Back of third finger on chin.
Motion.	Rigid-arm.

Division 11. Similar to Fig. 186.

Teeth.	Left upper lateral and central.
Surface.	Labial.
Grasp.	Fist.
Fulcrum-point.	End of thumb on cutting edge of right central.
Motion.	Digital.

Division 12. Fig. 191.

Teeth.	Right lower molars and bicuspids.
Surface.	Lingual.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Rotary (or using side of stick with rigid-arm motion).

Division 13. Fig. 192.

Teeth.	Right lower cuspids and incisors.
Surface.	Lingual.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger from cutting edge of incisors to first bicuspid.
Motion.	Rotary.

Division 14. Fig. 193.

Teeth.	Left lower cuspid, bicuspids and molars.
Surface.	Lingual.
Grasp.	Pen-holder.
Fulcrum-point.	End of second finger on labial surface of lower incisors.
Motion.	Both rigid-arm and rotary.

Division 15. Fig. 194.

Teeth.	Left upper molars and bicuspids.
Surface.	Lingual.
Grasp.	Pen-holder
Fulcrum-point.	End of third finger on labial surface of right lower lateral or cuspid.
Motion.	Rigid-arm (or third finger on masticating surface of right upper bicuspid, rotary motion).

Division 16. Fig. 195.

Teeth.	Left upper cuspid and upper incisors.
Surface.	Lingual.
Grasp.	Pen-holder.
Fulcrum-point.	End of second or third finger on cutting edge of right upper cuspid.
Motion.	Rotary.

Division 17. Fig. 196.

Teeth.	Right upper cuspid, bicuspids and molars.
Surface.	Lingual.
Grasp.	Pen-holder.
Fulcrum-point.	Back of third or fourth finger on chin.
Motion.	Rotary.

PROPOSED MODEL COURSE FOR THE EDUCATION AND TRAINING OF THE DENTAL HYGIENIST.

At the request of several persons who are interested in the problem of educating and training the dental hygienist, the writer has outlined what he considers to be a model course for this purpose.

The curriculum is based upon the original conception of the service for which the dental hygienist was created. The announcement of the first course in September, 1913, is quoted as follows:

"In the last few years there has been a great demand for women as hygienists and prophylactic operators in dental offices, for it is a well-known fact that at least 80 per cent. of dental diseases can be prevented by following a system of treatment and cleanliness.

There is now also developing a demand for these women in public institutions such as schools, hospitals and sanitariums. The scientists and learned professional men have no means of spreading their findings and knowledge for the prevention of disease to the public except through pamphlets, newspapers and magazine articles. Although these have done good service they are not so efficient as teachers of hygiene and dental prophylactic workers would be."

There is a noticeable tendency on the part of some training schools to divert the dental hygienist from her true field of service by devoting a portion of the course to training in chair assistance to dentists and oral surgeons. Although the need of dentists and oral surgeons for trained assistants is very apparent, it must be definitely understood that this assistant should not be the dental hygienist. Her field of service is in no way analogous to that of the nurse or chair assistant. It is very desirable that she should be competent and willing to coöperate in any way to maintain the routine of an office or dispensary, but it is not desirable that her efforts should be continually diverted into fields of service which do not require her highly specialized training. The dental hygienist, as the original announcement shows, was created to be, primarily, an educator for hygiene and secondarily, a dental prophylactic operator.

In the following outline the daily schedule is planned so that the majority of the lectures occur in the morning periods when the mind is alert and the student is most receptive. The afternoon work for the greater part of the course is completed at three o'clock, and at no period is it continued after four o'clock. It is essential that the student shall have at least two hours of daylight for outdoor exercise and recreation before devoting the evening to study and review. A very definite plan has been followed of having the practical training advance only as the theory can be assimilated. The courses in Physics, Elementary and Biologic Chemistry, Physiology, and Dental Histology could be strengthened by the addition of some practical laboratory work.

The lecture periods during March and April are devoted to training the true teacher of hygiene. The month of May can be utilized for broadening the clinical experience of the student. There should be an opportunity during this month for the student to put into practice the teaching of hygiene in conjunction with the dental prophylactic treatment. Several periods have been reserved throughout the course for lectures on special subjects of interest to the class.

DENTAL HYGIENISTS' DAILY PROGRAM—COURSE OF STUDY.

Last Week of September. (First Semester.)

Sept.	Monday.	Tuesday.	Wednesday.	Thursday	Friday.	Saturday
9–10	Anatomy and General Histology	Physiology	Anatomy and General Histology	Physiology	Anatomy and General Histology	Physiology
10–11	. . . .	Special Anatomy (Head, Teeth, Jaws)	. .	Special Anatomy (Head, Teeth, Jaws)		
2–3	Physics		Physics		Physics	

October.

9–10	Anatomy and General Histology	Physiology	Anatomy and General Histology	Physiology	Anatomy and General Histology	Physiology
10–11	Physics	Special Anatomy (Head, Teeth, Jaws)	Tooth Carving	Special Anatomy (Head, Teeth, Jaws)	Tooth Carving	Special Anatomy (Head, Teeth, Jaws)
11–12.30	Tooth Carving	Tooth Carving		Tooth Carving		Tooth Carving
2–3	Dental Histology	Bacteriology and Sterilization	Dental Histology	Bacteriology and Sterilization	Dental Histology	

November.

9–10	Anatomy and General Histology	Physiology	Manikin Demonstration	Physiology	Anatomy and General Histology	Manikin Demonstration
10–11	Elementary Biologic Chemistry	Manikin Practice		Special Anatomy (Head, Teeth, Jaws)	Elementary Biologic Chemistry	
11–12.30	Manikin Practice			Manikin Practice	Manikin Practice	
2–3	Dental Histology	Bacteriology and Sterilization	Comparative Dental Anatomy	Bacteriology and Sterilization	Comparative Dental Anatomy	

December to Christmas Holidays.

9–10	Anatomy and General Histology	Physiology	Manikin Demonstration	Physiology	Anatomy and General Histology	Manikin Demonstration
10–11	Deposits and Accretions upon Teeth	Manikin Practice		Deposits and Accretions upon Teeth	Dento-Chemistry	
11–12.30	Manikin Practice			Manikin Practice	Manikin Practice	
2–3	Inflammation	Dental Caries	. . . . .	Dental Caries		

January.

9–12	Practical Work Children.					
2–3	Dental Prophylaxis	Pyorrhea Alveolaris	Special	Pyorrhea Alveolaris	Dental Prophylaxis	
3–4	. . . . .	Malocclusion	. . . . .	Malocclusion		

February. (Second Semester.)

9–12	Practical Work, Children					
2–3	Dental Prophylaxis	Alveolar Abscess and Focal Infection	. . . . .	Alveolar Abscess and Focal Infection	Dental Prophylaxis	
3–4	Mouth Manifestations of Systemic Disease	Communicable Diseases	. . . . .	Odontalgia	Dermatology	

March.

	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
9–12			Practical Work, Adults			
2–3	Nutrition and Dietetics	Radiography	Nutrition and Dietetics	Radiography	Nutrition and Dietetics	
3–4	General Hygiene	General Hygiene	.....	General Hygiene	Prenatal Hygiene and Infant Feeding	

April

9–12			Practical Work, Adults			
2–3	Nutrition and and Dietetics	Pedagogy	Personal Hygiene	Pedagogy	Personal Hygiene	
3–4	School and Child Hygiene	Industrial Hygiene	.....	School and Child Hygiene	Public Health Organization and Administration	

May

The entire month of May is spent on Practical Work.

SUMMARY—FIRST SEMESTER

	Sept. Hours.	Oct. Hours.	Nov. Hours.	Dec. Hours.	Jan. Hours.	Total hrs. 1st Sem.
Anatomy and General Histology	3	12	8	7	..	30
Physiology	3	12	8	7	..	30
Physics	3	4	..	..	..	7
Elementary Biologic Chemistry	..	..	8	..	..	8
Dento-Chemistry	..	..	..	3	..	3
Special Anatomy of Head, Teeth, Jaws	2	12	4	..	..	18
Dental Histology	..	12	4	..	..	16
Bacteriology and Sterilization	..	8	8	..	..	16
Comparative Dental Anatomy	..	..	8	..	..	8
Dental Caries	..	..	..	6	..	6
Deposits and Accretions upon Teeth	..	..	..	6	..	6
Inflammation	..	..	..	3	..	3
Dental Prophylaxis	..	..	..	..	6	6
Pyorrhea Alveolaris	..	..	..	..	6	6
Malocclusion	..	..	..	..	6	6
Total	11	60	48	32	18	169
		Tooth Carving	Manikin Practice	Manikin Practice	Practical Work, Children	
Practical Work	..	32	44	33	54	Total 163

SUMMARY—SECOND SEMESTER

	Feb. Hours.	Mar. Hours.	Apr Hours.	May Hours.	Total hours.
Dental Prophylaxis	8	..	..	..	8
Alveolar Abscess and Focal Infection	8	..	..	..	8
Odontalgia	4	..	..	..	4
Dermatology	4	..	..	..	4
Mouth Manifestations, Systemic Disease	4	..	..	..	4
Communicable Diseases	4	..	..	..	4
Nutrition and Dietetics		12	4		16
General Hygiene		12			12
Radiography		8			8
Personal Hygiene			8		8
Pedagogy	..	..	8		8
Pub. Health, Organization, Administration	..	..	4		4
School and Child Hygiene	..	..	8		8
Industrial Hygiene	..	..	4		4
Prenatal Hygiene and Infant Feeding	..	4			4
Total	32	36	36		104
	Practical Work Adult 72	Practical Work 72	Practical Work 72	Practical Work 112	Total 328

INDEX.

A

Abscess, blind, 206
Adenoids, 44
Air cells, anatomy of, 24
  ethmoidal, 26
  mastoid, 26
Alimentary tract in dental prophylaxis, 227
Alveolar process, anatomy of, 34, 47
  histology of, 74
Anterior aspect of skull, 22
  fossa of skull, 18
  lacerated foramen, 19
  nares, 23
  palatine fossa, 22
Antra of Highmore, anatomy of, 24
Apical foramen of teeth, 46
Aqueous humor, 28, 29
Arch of teeth, definition of, 116
Artery, maxillary, internal, anatomy of, 42
Arthritis, oral infection and, 222
Articulation, temporomaxillary, 36
Auditory canal, external, 29
  meatus, external, 29

B

Baboon, teeth of, 91
Bacteremia, 216
Bacteria, propagation of, dental prophylaxis and, 230
Base of skull, 19
Bicuspid teeth, occlusion of, 99
Bicuspids, anatomy of, 50
  individual characteristics of, 52
Blind abscess, 206
Blood corpuscles, 137
  normal, constituents of, 137
  plasma, 138
  platelets, 137
  supply of dental tissues, 40
Bloodvessels of peridental membrane, 72
  of pulp, 64
Bone, inflammation of, 147
    etiology of, 147
  repair of, 147, 148
Bones, maxillary, inferior, anatomy of, 34
    superior, anatomy of, 33
  palate, anatomy of, 34
Bony sinuses, anatomy of, 24
Brushing of teeth in prophylaxis, 274
Brush-wheel in polishing of teeth, 272
Buccal surface of teeth, definition of, 117
Bull-frog, teeth of, 82

C

Callus, definition of, 148
Capsular ligaments, 94
Capsule of Tenon, 26
Caries, dental, 112, 173, 186
Carnivorous animals, teeth of, 85
Catarrhal inflammation, 136
Cell, 223
  life, factors for, 225
Cells, air, anatomy of, 24
Cementoblasts of peridental membrane, 71
Cementum, anatomy of, 46
  canaliculi of, 63
  cells of, 63
  function of, 64
  histology of, 61
  lacunæ of, 63
  lamellæ of, 61
Cheeks, anatomy of, 37
Choanæ, 23
Chordi tympani nerve, 42
Choroid, 28
Ciliary body, 28
  muscle, 28
  processes, 28
Circulation, normal, 137
Circumvallate papillæ, 39
Coats of eye, 27, 28
Cock's crest, 18
Condyle of jaw, 36
Conjunctiva, 26
Conjunctivitis, oral infection and, 221
Connective tissue, 138
Connective-tissue cells of pulp, 64
Coronal suture, 17
Coronoid process, 36
Corti, organ of, 32
Cranial nerves, anatomy of, 40, 42
Cranium, anatomy of, 17
Crista galli, 18
Crocodiles, teeth of, 82
Crystalline lens, anatomy of, 29
Curve of Spee, 100

Cuspids, anatomy of, 49
distinguishing points between upper and lower, 50
Cysts, 211

D

Deciduous teeth, premature loss of, malocclusion and, 127
Dental caries, 112, 173
areas of immunity to, 112
of susceptibility to, 112
lactic acid in, 180
malocclusion and, 113
prophylaxis and, 233
saliva in, 182
clinics, educational and preventive, for school children, 302
industrial, dental hygienist in, 301
municipal, dental hygienist in, 301
crypt, formation of, 76
follicle, formation of, 76
foramen, inferior, 36
granuloma, 206
hygienist, broad field of service of, 299
in hospitals, 301
in industrial dental clinics, 301
in municipal dental clinics, 301
in private practice, 299
proposed model course for education and training of, 324
in public schools, first at work in, 307
in sanatoriums, 301
infections, chronic, systemic effects from, 218
focus of, 218
systemic effects from, 215
mechanism, human, 92
papilla, formation of, 75
prophylaxis, 223
alimentary tract in, 227
bacterial propagation in, 230
brushing in, 274
of buccal surfaces, 280
instructions for, 280
of labial surfaces, 280
of lingual surfaces, 283
of masticating surfaces, 286
number of daily, 286
in children, 273
decomposing food débris in, 228
dental caries and, 233
dentifrices in, 287
diet in, 294
examination of adult mouth in, 235
floss silk in, 288
gums in, 276
Dental prophylaxis, home care of mouth and, 274
hygienist in, 235
instrumentation in, 239, 249
four motions in, 244
instruments in, 246
keratin in, 275
lime-water in, 291
of lower jaw, instrumentation in, 240, 249
polishing in, 261
brush-wheel in, 272
floss in, 272
system of, 263
principles of, 234
in private practice, system of, 300
pyorrhea alveolaris and, 232
surfaces of teeth in, 238
syphilis and, 232
systemic infection and, 232
tissue stimulation in, 276
tooth-brushes and, 278
treatment in, 238
tuberculosis and, 232
of upper jaw, instrumentation in, 241, 255
pulp, inflammation of, differential diagnosis of, 195
ridge, formation of, 75
tissues, blood supply of, 40
nerve supply of, 40
Dentin, anatomy of, 46
caries of, 186
fibrils of, 61
function of, 61
histology of, 60
matrix of, 61
secondary, histology of, 66
tubules of, 61
Dentifrices in dental prophylaxis, 287
Denture, human, study of, 95
Diet in dental prophylaxis, 294
Diffuse osteomyelitis, 211
Digastric muscle, 93
Distal surface of teeth, definition of, 116
Dogs, teeth of, 87

E

Ear, anatomy of, 29
cochlea of, 32
drum of, 30
external, 29
internal, 31
labyrinth of, 31
middle, 29
ossicles of, 30
function of, 31
vestibule of, 32
Elephant, teeth of, 92
Eminentia articularis, 36
Enamel, anatomy of, 46

Enamel, functions of, 60
histology of, 58
organ, formation of, 75
rods, histology of, 58
Endocarditis, oral infection and, 222
Endolymph, 31
Endothelial cells, 138
leukocytes, 138
Eosinophiles, 138
Ethmoidal air cells, 26
Eustachian tube, anatomy of, 31
Evolution of tooth forms, 80
Exacerbations, 209
Expression, muscles of, 37
External auditory canal, 29
meatus, 29
Extraction of permanent teeth, malocclusion and, 127
Exudation, definition of, 142
Exudative inflammation, 136
Eye, coats of, 27
fibrous, 27
nervous, 28
vascular, 27
Eyeball, interior of, anatomy of, 28
Eyes, anatomy of, 26
refracting media of, 29
yellow spot of, 28

F

Face, anatomy of, 22
Facial nerve, anatomy of, 42
Fauces, anatomy of, 44
Fibrinous exudation, definition of, 142
Fibroblasts of peridental membrane, 71
Fibrous coats of eye, 27
Fifth cranial nerve, anatomy of, 40
Fishes, teeth of, 82
Fissure, sphenoidal, 19
sphenomaxillary, 22
Fistula, definition of, 144
Floor of nose, anatomy of, 24
Floss silk in dental prophylaxis, 288
in polishing of teeth, 272
Fones's plan of mouth hygiene proposed in 1914, 303
Food débris, decomposition of, dental prophylaxis and, 228
mastication of, 105
Foramen, lacterated, anterior, 19
middle, 19
optic, 19
ovale, 19
rotundum, 19
Fossa, palatine, anterior, 22
posterior, 22
of skull, anterior, 18
middle, 19
posterior, 19
zygomatic, 22
Fossæ, glenoid, 22
nasal, 22
Fossæ, sublingual, 36
Fovea centralis, 28
Frenum, 37
Frontal sinuses, anatomy of, 25

G

Gastritis, oral infection and, 222
Geniohyoid muscle, 93
Glands, lachrymal, 29
parotid, 43
salivary, 43
sublingual, 36, 44
submaxillary, 36, 44
tear, 29
Glenoid fossæ, 20
Gnarled enamel, 59
Granular layer of Tomes, 61
Granuloma, dental, 206
Gums in dental prophylaxis, 276
histology of, 74

H

Hard palate, anatomy of, 37
Head, anatomy of, 17
Healing by first intention, definition of, 145
by second intention, definition of, 146
Highmore, antra of, anatomy of, 24
Horse, teeth of, 92
Hospitals, dental hygienist in, 301
Human dental mechanism, 92
denture, study of, 95
Hygienist, dental, service of, in prophylaxis, 235

I

Incisors, anatomy of, 47
individual characteristics of, 49
Inclined plane of teeth, definition of, 116
Industrial dental clinics, dental hygienist in, 301
Inferior dental foramen, 36
maxillary bones, anatomy of, 34
Inflammation, 136
of bone, 147
etiology of, 147
causes of, 138
catarrhal, 136
chronic, definition of, 144
circulatory disturbances and, 140
classification of, 136
definition of, 136
of dental pulp, differential diagnosis of, 195
disturbance of function in, 141
exudative, 136
heat in, 141

Inflammation, hyperemia in, 141
injury in, 140
interstitial, 136
pain in, 141
parenchymatous, 136
of peridental membrane, differential diagnosis of, 195
redness in, definition of, 141
suppurative, 136
swelling in, 141
symptoms of, 141
ulcerative, 136
Instrumentation in dental prophylaxis, 239, 249
Internal maxillary artery, anatomy of, 42
Interproximal spaces, 113
Interstitial inflammation, 136
Intracellular substance of pulp, 66
Iris, 28
Iritis, oral infection and, 222

J

Jaw, condyle of, 36
lower, instrumentation of, in dental prophylaxis, 240, 249
upper, instrumentation of, in dental prophylaxis, 241, 255
Jaws, development of, 78
growth of, maloeclusion of teeth and, 128

K

Keratin in dental prophylaxis, 275

L

Labial surface of teeth, definition of, 117
Labyrinth of ear, 31
Lachrymal apparatus, 29
gland, 29
sac, 29
Lactic acid in dental caries, 180
Lambdoid suture, 17
Lamina, formation of, 75
Lateral aspect of skull, 22
Lemurs, teeth of, 92
Lesion, definition of, 140
Leukocytes, endothelial, 138
mononuclear, 138
polymorphonuclear, 137
Ligaments, capsular, 94
sphenomandibular, 94
stylomandibular, 94
Lime-water in dental prophylaxis, 291
Lingual surface of teeth, definition of, 117
tonsil, 40, 44
Lips, anatomy of, 37
Lower teeth, occlusion of, 96
Ludwig's angina, 213
Lymphatics of mouth, anatomy of, 43
of peridental membrane, 72
of pulp, 65
Lymphocytes, 138

M

Macula lutea, 28
Malar process, 34
Maloeclusion of teeth, 112
classification of, 120
Angle's, 121
definition of, 119
etiology of, 126
extraction of permanent teeth and, 127
lack of use and, 128, 132
pernicious habits and, 127
premature loss of deciduous teeth and, 127
growth of jaws in, 128
individual, 119
in school children, 310
Mandible, 93
anatomy of, 34
muscles moving, 36
Manikins, schedule of lessons on, 318
Masseter muscle, 93
Mast cells, 138
Mastication of food, 105
muscles of, 37, 93
Mastoid air cells, 26
antrum, anatomy of, 31
Maxillary artery, internal, anatomy of, 42
bones, inferior, anatomy of, 34
superior, anatomy of, 33
sinuses, anatomy of, 24
infection of, 213
Meckel's ganglia, 32
Mental foramina, 35
Mesial surface of teeth, definition of, 116
Middle fossa of skull, 19
lacerated foramen, 19
Molar teeth, occlusion of, 99
Molars, lower, anatomy of, 54
upper, anatomy of, 52
individual characteristics of, 54
Monkey, teeth of, 88
Mononuclear leukocytes, 138
Mouth, adult, examination of, in prophylaxis, 235
anatomy of, 32
home care of, in dental prophylaxis, 274
hygiene, communicable diseases and, 313
in public schools of Bridgeport, Conn., report of five years of, 302
retardation of school children and, 311

Mouth, lymphatics of, anatomy of, 43
mucous membrane of, anatomy of, 37
roof of, anatomy of, 24
Mouth-brushing, 278
Mucous membrane of mouth, anatomy of, 37
Municipal dental clinics, dental hygienist in, 301
Muscles, digastric, 93
of expression, 37
geniohyoid, 93
masseter, 93
of mastication, 37, 93
moving mandible, 36
mylohyoid, 93
pterygoid, 93
temporal, 93
Mylohyoid muscle, 93
ridge, 36
Myositis, oral infection and, 222

N

Nares, anterior, 23
posterior, 23
Nasal cavity, blood supply of, 24
nerve supply of, 24
duct, 29
fossæ, anatomy of, 23
nerves, 18
process, 34
septum, 23
Nasmyth's membrane, 59
Necrosis of bone, 148
definition of, 140
Nephritis, oral infection and, 222
Nerve supply of dental tissues, 40
of ears and teeth, interconnection of, 32
Nerves, cranial, anatomy of, 40, 42
nasal, 18
of peridental membrane, 72
of pulp, 65
Nervous coats of eye, 28
Neuman, sheaths of, 60
Neuralgia, 197
causes of, 198
definition of, 197
nature of, 197
quinti major, 198
minor, 198
treatment of, 201
type of, 197
varieties of, 198
Neuritis, oral infection and, 222
Nose, floor of, anatomy of, 24

O

Occlusion of teeth, 45, 97
definition of, 116, 117
Odontalgia, 191
causes of, 194
definition of, 191
local, 194
obscure, 196
referred, 196
Odontoblasts, 64
Olfactory groove, 18
Optic disk, 28
foramen, 19
Oral foci, 218
distribution of infection from, 218
proof of systemic infection from, 218
secondary lesions in, 219
infections, arthritis and, 222
conjunctivitis and, 221
endocarditis and, 222
gastritis and, 222
general and special diseases originating from, 221
iritis and, 222
myositis and, 222
nephritis and, 222
neuritis and, 222
otitis media and, 221
pharyngitis and, 221
pyemia and, 222
relation of, to general health, 203
septicemia and, 222
tonsillitis and, 221
toxemia and, 222
Orbits, anatomy of, 22
Organ of Corti, 32
Ossicles of ear, 30
function of, 31
Osteoblasts of peridental membrane, 71
Osteomyelitis, definition of, 147
diffuse, 211
Ostitis, 210
definition of, 147
Otic ganglia, 32
Otitis media, oral infection and, 221
Otoliths, 32

P

Pain, definition of, 192
varieties of, 193
Palate bones, anatomy of, 34
hard, anatomy of, 37
process, 34
soft, anatomy of, 37
Palatine fossa, anterior, 22
posterior, 22
Papillæ of tongue, 39
Parenchymatous inflammation, 136
Parotid glands, 43
"Path of least resistance," definition of, 143
Periapical infections, 204
acute, 206

Periapical infections, tooth apex in, 208
Peridental membrane, anatomy of, 47
bloodvessels of, 72
cells of, 71
cementoblasts of, 71
changes in, with age, 73
definition of, 67
epithelial elements of, 72
fibers of, 68
arrangement of, 68
fibroblasts of, 71
function of, 72
histology of, 64, 67
inflammation of, differential diagnosis of, 195
lymphatics of, 72
nerves of, 72
osteoblasts of, 71
white fibrous connective tissue of, 68
Perilymph, 31
Periodontitis, acute local, 195
chronic local, 195
general, 196
Periostitis, definition of, 147
Permanent teeth, extraction of, malocclusion and, 127
Phagocytosis, definition of, 141
Pharyngeal tonsil, 44
Pharyngitis, oral infection and, 221
Pointing, definition of, 143
Polishing of teeth in prophylaxis, 261
brush-wheel in, 272
floss in, 272
system of, 263
Polymorphonuclear leukocytes, 137
Posterior fossa of skull, 19
nares, 23
palatine fossa, 22
Protruding teeth, definition of, 117
Pterygoid muscles, 93
Pulp, anatomy of, 46
bloodvessels of, 64
cavity, anatomy of, 46
chamber, anatomy of, 46
connective-tissue cells of, 64
function of, 66
histology of, 64
intercellular substance of, 64
lymphatics of, 65
nerves of, 65
odontoblasts of, 64
Pulpitis, acute, 195
Pupil of eye, 28
Pyemia, 216
oral infection and, 222
Pyorrhea alveolaris, 166
definition of, 166
dental prophylaxis and, 232
etiology of, 169
history of, 166
pathology of, 166
prevention of, 169
treatment of, 171

R

Refracting media of eye, 29
Repair of bone, 147
definition of, 145
Retina, 28
Retruding teeth, definition of, 117
Rodents, teeth of, 88
Roof of mouth, anatomy of, 24
Root canals, anatomy of, 46
Rhinoceros, teeth of, 92

S

Sac, lachrymal, 29
Saccule, 32
Sagittal suture, 17
Saliva, constituents of, 150
decomposition of, 154
in dental caries, 182
Salivary glands, anatomy of, 43
Sanatoriums, dental hygienist in, 301
Sapremia, 217
Sella turcica, 19
Semicircular canals, anatomy of, 32
Sensation, causes of, 192
definition of, 192
laws governing, 192
Septicemia, definition of, 143
oral infection and, 222
Septum, nasal, 23
Serous exudation, definition of, 142
Seventh cranial nerve, anatomy of, 42
Sheaths of Newman, 61
Sinus, definition of, 144
sphenoidal, anatomy of, 25
Sinuses, frontal, anatomy of, 25
maxillary, anatomy of, 24
Skull, anatomy of, 17
anterior aspect of, 22
base of, 19
fossa of, anterior, 18
middle, 19
posterior, 19
lateral aspect of, 22
Snakes, teeth of, 82
Soft palate, anatomy of, 37
Spee, curve of, 100
Sphenoidal fissure, 19
sinus, anatomy of, 25
Sphenomandibular ligament, 94
Sphenomaxillary fissure, 22
Stylomandibular ligament, 94
Sublingual fossæ, 36
glands, 36, 44
Submaxillary glands, 36, 44
Superior maxillary bones, anatomy of, 33
Suppurative exudation, definition of, 142
inflammation, 136
Suspensory ligament of lens, 29
Sutures, coronal, 17
lambdoid, 17
sagittal, 17

Sword fish, teeth of, 92
Symphysis menti, 35
Syphilis, dental prophylaxis and, 232
Systemic infection, dental prophylaxis and, 232

T

Tartar, chemistry of, 152
color of, 162
definition of, 149
development of, 157
formation of, 150
hardness of, 160
removal of, 160
solubility of, 163
Tear gland, 29
Teeth, accretions on, 149
alveolar process of, 47
histology of, 74
anatomy of, 45, 47
apical foramen of, 46
arch of, definition of, 116
attachment of, 66
of baboon, 91
bicuspids, anatomy of, 50
occlusion of, 99
buccal surface of, definition of, 117
of bullfrog, 82
of carnivorous animals, 85
cementing substance of, 58
cementum of, anatomy of, 46
histology of, 61
of crocodiles, 82
cuspids, anatomy of, 49
deciduous, anatomy of, 56
premature loss of, malocclusion and, 127
dentin of, anatomy of, 46
histology of, 60
secondary, histology of, 66
deposits on, 149
distal surface of, definition of, 116
of dogs, 87
of elephant, 92
enamel of, anatomy of, 46
histology of, 58
eruption of, approximate age for, 57
of fishes, 82
formation of, 75
forms of, evolution of, 80
functions of, secondary, 91
supplementary, 109
of horse, 92
histology of, 58
incisors, anatomy of, 47
inclined plane of, definition of, 116
infected, source of systemic disease, 213
labial surface of, definition of, 117
of lemurs, 92
lingual surface of, definition of, 117
lower, occlusion of, 96
Teeth, malocclusion of, 112
classification of, 120
Angle's, 121
definition of, 119
etiology of, 126
extraction of permanent teeth, 127
lack of use and, 128, 132
pernicious habits and, 127
premature loss of deciduous teeth and, 127
growth of jaws in, 128
individual, 119
in school children, 310
as a masticating machine, 80
mesial surface of, definition of, 116
model of, definition of, 117
molars, lower, anatomy of, 54
occlusion of, 99
upper, anatomy of, 52
of monkey, 88
nomenclature of, 47
normal contacts in, 115
occlusion of, 45, 99
definition of, 116, 117
peridental membrane of, anatomy of, 47
histology of, 64, 67
permanent, extraction of, malocclusion and, 127
protruding, definition of, 117
pulp of, anatomy of, 46
cavity, anatomy of, 46
chamber, anatomy of, 46
histology of, 64
retruding, definition of, 117
of rhinoceros, 92
of rodents, 88
root canal of, anatomy of, 46
of snakes, 82
surfaces of, in dental prophylaxis, 238
of sword fish, 92
of turtles, 82
upper, occlusion of, 96
of walrus, 92
Temporal muscle, 93
Temporomaxillary articulation, 36
Tenon, capsule of, 26
Tic douloureux, 198
Tissue stimulation in dental prophylaxis, 276
Tomes, granular layer of, 61
Tongue, anatomy of, 38
papillæ of, 39
Tonsil, lingual, 40
Tonsillitis, oral infection and, 221
Tonsils, anatomy of, 44
Tooth germ, formation of, 75
Tooth-brushes, dental prophylaxis and, 278
Toxemia, 216
oral infection and, 222
Trifacial nerve, anatomy of, 40

Tuberculosis, dental prophylaxis and, 232
Turkish saddle, 19
Turtles, teeth of, 82
Tympanic membrane, 30

U

Ulcer, definition of, 144
Ulcerative inflammation, 136
Upper teeth, occlusion of, 96
Utricle, 32

V

Vascular coats of eye, 27
Vitreous humor, 29

W

Walrus, teeth of, 92
Wharton's duct, 36

Z

Zygomatic fossa, 22

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